THE

JOURNAL

OF THE

ROYAL AGRICULTURAL SOCIETY

OF ENGLAND.

VOLUME THE TWELFTH.

PRACTICE WITH SCIENCE.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1851.

THESE EXPERIMENTS, IT IS TRUE, ARE NOT EASY; STILL THEY ARE IN THE POWER OF EVERY THINKING HUSBANDMAN. HE WHO ACCOMPLISHES BUT ONE, OF HOWEVER LIMITED APPLICATION, AND TAKES CARE TO REPORT IT FAITHFULLY, ADVANCES THE SCIENCE, AND, CONSEQUENTLY, THE PRACTICE OF AGRICULTURE, AND ACQUIRES THEREBY A RIGHT TO THE GRATITUDE OF HIS FELLOWS, AND OF THOSE WHO COME AFTER. TO MAKE MANY SUCH IS BEYOND THE POWER OF MOST INDIVIDUALS, AND CANNOT BE EXPECTED. THE FIRST CARE OF ALL SOCIETIES FORMED FOR THE IMPROVEMENT OF OUR SCIENCE SHOULD BE TO PREPARE THE FORMS OF SUCH EXPERIMENTS, AND TO DISTRIBUTE THE EXECUTION OF THESE AMONG THEIR MEMBERS.

VON THAER, *Principles of Agriculture.*

London: Printed by WILLIAM CLOWES and SONS, Stamford Street.

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APPENDIX.

PLATES.

DIRECTIONS TO BINDER.

The Binder is desired to place all the Appendix matter, with Roman numeral folios, at the *end* of the Journal, excepting Titles and Contents, which are in all cases to be placed at the *beginning* of the Part or Volume.

In reprints of the Journal, all Appendix matter (and in one instance an Article in the body of the Journal), which at the time had become obsolete, were omitted; the Roman numeral folios, however (for convenience of reference), being reprinted without alteration in the Appendix matter retained.

JOURNAL

OF THE

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

I.—*On Agricultural Chemistry,—especially in relation to the Mineral Theory of Baron Liebig.* By J. B. Lawes, of Rothamsted, and Dr. J. H. Gilbert.

It was under the auspices of the British Association that Professor Liebig in the year 1840 first promulgated his views on the subject of Agricultural Chemistry; and however much some may be disposed to differ from him in opinion on special points therein treated of, few we presume will deny that from the appearance of the first edition of Professor Liebig's work on 'Organic Chemistry in its relations to Agriculture and Physiology' we may date a spirit of investigation into Agricultural Chemistry such as had not previously been manifested in this country. Indeed, we conceive that in looking back to the words of his preface in 1840, wherein he says, "I shall be happy if I succeed in attracting the attention of men of science to subjects which so well merit to engage their talents and energies,"—in this respect, at least, Professor Liebig must feel that his efforts have been rewarded far beyond what his most sanguine expectation could at the time have led him to hope for. It could scarcely be expected, however, that with the progress of inquiry, such as is here invited, there should not result from time to time some, and perhaps material, modifications on questions which it is admitted the facts already at command were not competent satisfactorily to solve; indeed, if it were not so, if no further facts were requisite, and the views as then put forth were all and in their manifold detail already fully substantiated, where the necessity for further investigation of the subject? Surely it would be labour lost!

Professor Liebig has indeed himself contributed to the development of the subject, in the several succeeding editions of his works; and also in his 'Letters on Chemistry,' and in other publications; and he has, in a new and enlarged edition of the second-mentioned work, namely, his 'Letters on Chemistry,' pub-

lished only in May last, given the result of his latest researches in agricultural and physiological chemistry.

Among other labourers in this important field of investigation of late years we may state that one of ourselves was occupied several years, prior to the appearance of the first edition of Professor Liebig's work, in investigating the action of different chemical combinations when applied as manures to the most important crops of the farm; and that since the year 1843 we have been conjointly engaged in systematically investigating the subject of agricultural chemistry in a more extended sense than that alone implied in the question of the action of special substances as manures.

In the course of this inquiry, the whole tenor of our results, and also of information derived from intelligent agricultural friends, upon every variety of land in Great Britain, has forced upon us opinions different from those of Professor Liebig on some important points; and more especially in relation to his so-called "Mineral Theory," which is embodied in the following sentence, to be found at page 211 of the third edition of his work on Agricultural Chemistry, where he says "The crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure."

It will be easily conceived, therefore, that it was with much interest that we turned to those pages of the new edition of Baron Liebig's 'Letters,' which treat of the food of plants, in order to ascertain how far the facts of the last few years had tended to alter or modify his views on points wherein our own differed from those which he had hitherto published.

It was in reference to our opinions on the views of Liebig, as given in the axiom already quoted, that Mr. Pusey, when giving, in the last number of this Journal, a review of the progress of agriculture during the last eight years, called attention to what he regarded as conclusive evidence against those views in some of our results, which had appeared from time to time in former Numbers; and it is in reply to these remarks of Mr. Pusey that Professor Liebig has devoted a note of four or five closely printed pages in the 'Letters,' just published, to an attack upon our experiments and opinions, as set forth by Mr. Pusey in the article referred to.

Of the vast importance, both in a scientific and practical point of view, of correct ideas on the subject here at issue, a judgment may be formed by the manner in which the Professor himself speaks of his "Mineral Theory," in the new edition of his 'Letters.' Thus, at page 483, he says of the agriculturists of England, that "sooner or later they must see that in this so-called 'mineral theory,' in its development and ultimate perfection, lies the whole future of agriculture."

The importance of the subject, on such high authority as that of Professor Liebig himself, as thus stated, will, we trust, be considered sufficient reason for bringing before the readers of this Journal a brief statement of the opinions to which our results have led us; but as Professor Liebig has said, in regard to our experiments, that "they are entirely devoid of value, as the foundation for general conclusions;" and, further, that "with a knowledge of our experience of the effects of fallow and of production on the large scale, it requires all the courage derived from the want of intimate acquaintance with the subject" to make the statements we have done, it seems incumbent on us to recall attention to the plan and object of the experiments themselves, before entering upon the consideration of the results which they have provided.

Looking upon the subject in a chemical point of view only, it would seem that an analysis of the soil upon which crops were to be experimentally grown, as well as a knowledge of the composition of the crop, should be the first points attained, with the view of deciding in what constituents the soil was deficient; and at the commencement of our more systematic course of field experiments the importance of these points was carefully considered. When we reflect, however, that an acre of soil six inches deep may be computed to weigh about 1,344,000 lbs. (though the roots of plants take a much wider range than this), and taking the one constituent of ammonia or nitrogen as an illustration, that in adding to this quantity of soil a quantity of ammoniacal salt containing 100 lbs. of ammonia—which would be an unusually heavy and very effective dressing—we should only increase the per-centage of ammonia in the soil by 0·0007, it is evident that our methods of analysis would be quite incompetent to appreciate the difference between the soil before and after the application,—that is to say, in its state of exhaustion, and of highly productive condition, so far as that constituent is concerned; and from our knowledge of the effects of this substance on wheat, we may confidently assert that the quantity of it supposed above would have given a produce at least double that of the unmanured land. The same kind of argument might, indeed, be adopted in reference to the more important of those constituents of a soil which are found in the ashes of the plants grown upon it, and we determined, therefore, to seek our results in another manner. Indeed, the imperfection of our knowledge of the productive quality of a soil, as derived from its percentage composition, has been amply proved by the results of analysis which have been published during the last ten years; and in corroboration we need only refer to the opinions of Professor Magnus on this subject, who, in his capacity of chemist to the "Landes-Oekonomie Kollegium" of

Prussia, has published the results of many analyses of soils. The truth is, that little is as yet known of what a soil either is or ought to be, in a chemical point of view; but when we call to mind the investigations of Professor Mulder, in relation to the organic acids found in soils, and of Mr. Way and others, as to the chemical and physical properties of soils, in relation to the atmosphere, and to saline substances exposed to their action in solution, we may at least anticipate for chemistry that she will ere long throw important light on this interesting but intricate subject.

In our field experiments, then, we have been satisfied with preserving specimens of the soils which were to be the subjects of them, and have sought to ascertain their deficiency, in regard to the production of different crops, by means which we conceive to be not only far more manageable, but in every way more conclusive and satisfactory in their result.

To illustrate—What is termed a rotation of crops is at least of such universality in the farming of Great Britain, that any investigation in relation to the agriculture of that country may safely be grounded on the supposition of its adoption. Let us, then, direct attention for a moment to some of the chief features of rotation. What is called a *course* of rotation is the period of years which includes the circle of all the different crops grown in that rotation or alternation. The crops which thus succeed each other, and constitute a rotation, may be two, three, four, or more, varying with the nature of the soil and the judgment of the farmer; but, whatever *course* be adopted, no individual crop — wheat, for example—is grown immediately succeeding one of the same description, but it is sown again only after some other crops have been grown, and at such a period of the rotation, indeed, as by experience it is known that the soil will, by direct manure or other means, have recovered its capability of producing a profitable quantity of the crop in question.

On carefully considering these established and well-known facts of agriculture, it appeared to us that, by taking soils either at the end of the rotation, or at least at that period of it when in the ordinary course of farming farm-yard-manure would be added before any further crop would be grown, we should then have the soils in what may be termed a *normal*, or, perhaps better still, a *practically* and *agriculturally exhausted state.*

Now, if it is found, in the experience of the farmer, that land of any given quality with which he is well acquainted, will not when in this condition of *practical exhaustion* yield the quantity he usually obtains from it of any particular crop, but that after applying farm-yard manure it will do so, it is evident that if we supply to different plots of this *exhausted land* the constituents of farm-yard manure, both individually and combined, and if

by the side of these plots we also grow the crop both without manure of any kind and with farm-yard-manure, we shall have obtained in the comparative results a far more satisfactory solution of the question as to what constituents were, in this ordinary course of agriculture, most in defect in respect to the production of the particular crop experimented upon, than any analysis of the soil could have given us. In other words, we should have before us very good ground for deciding to which of the constituents of the farm-yard manure the increased produce was mainly due on the plot provided with it, in the case of the particular crop: not so, however, unless the soil had been so far exhausted by previous cropping as to be considered *practically* unfit for the growth of that crop without manure. We lay particular stress on this exhaustion, because we believe that the vast discrepancy in the comparative results, with different manures, by different experimenters, arises more from irregularity in what may be called the *floating* capital of the soil than from irregularities in the original character of the soil itself, or from any other cause, unless we include the frequent faulty methods of application.

It is, then, by this *synthetic* rather than by the analytic method that we have sought our results; and in the carrying out of our object we have taken *Wheat* as the type of the cereal crops, *Turnips* as the type of the *root crops*, and *Beans* as the representative of the Leguminous corn crop, since these most frequently enter into rotation; and having selected for each of these a field which, agriculturally considered, was *exhausted*, we have grown the same description of crop upon the same land, year after year, with different chemical manures, and in each case with one plot or more continuously unmanured, and one supplied every year with a fair quantity of farm-yard-manure.

In this way 14 acres have been devoted to the continuous growth of *Wheat* since 1843, 8 acres to the continuous growth of *Turnips* from the same date, and 5 to 6 acres to that of Leguminous corn crops since 1847. Besides these we have made other field experiments—amounting in each year to from 30 to 40 on wheat, upwards of 90 on turnips, and 20 to 30 on beans—and also some on the growth of Clover, and some in relation to the chemical circumstances involved in an actual course of rotation, comprising Turnips, Barley, Clover, and Wheat, grown in the order in which they are here stated.

It may be stated, too, that in addition to these experiments on wheat and the other crops usually grown upon the farm as above referred to, we have for several years been much occupied also with the subject of the feeding of animals—viz. Bullocks, Sheep, and Pigs—as well as in investigating the functional actions of the

growing plant in relation to the soil and atmosphere; and in connexion with each of these subjects much laboratory labour has constantly been in progress.

The scope and object of our investigation has been therefore to examine, in the field, the feeding-shed, and the laboratory, into the chemical circumstances connected with the agriculture of Great Britain in its four main features; namely—

First, the production of the Cereal grain crops;
Secondly, that of Root crops;
Thirdly, that of the Leguminous corn and Fodder crops; and
Fourthly, and lastly, that of the consumption of food on the farm for its double produce of Meat and Manure.

So much then for the rationale and general plan of the experiments themselves, and we now propose to call attention to some of the results which they have afforded us.

Hitherto only part of the results of the wheat experiments of the harvests of 1844, 1845, and 1846, and of these seasons only, have been published; those on turnips, only for the seasons 1843, 1844, and 1845; those on the leguminous crops not at all as yet; and those on feeding, only as far as sheep are concerned, and chiefly too in relation to the one point only of the increase of *live weight* obtained from a given quantity of food, or its constituents. Of the laboratory results but few have been given in relation to any one of these branches up to the present time. The vast accumulation of results, indeed, will necessarily still further postpone the publication of them in any extended form; and hence it seems the more desirable to take advantage of the present opportunity to attempt to bring together into one view some of the general indications which have been arrived at in relation to a few of the more important points.

With this view, it is to the field experiments on wheat that we shall chiefly confine our attention on this occasion; for wheat, which constitutes the principal food of our population, is with the farmer the most important crop in his rotation, all others being considered more or less subservient to it; and it is, too, in reference to the production of this crop in agricultural quantity that the mineral theory of Baron Liebig is perhaps more prominently at fault than in that of any other.

It is true that, in the case of vegetation in a native soil, unaided by art, the mineral constituents of the plants being furnished from the soil, the atmosphere is found to be a *sufficient* source of the nitrogen and carbon; and it is the supposition that these circumstances of *natural vegetation* apply equally to the various crops when grown *under cultivation* that has led Baron Liebig to suggest that, if by artificial means we

accumulate within the soil itself a sufficiently liberal supply of those constituents found in the ashes of the plant—essentially soil constituents, we shall by this means be able in all cases to increase thereby the assimilation of the vegetable or atmospheric constituents in a degree sufficient for agricultural purposes. But agriculture is itself an *artificial* process; and it will be found that, as regards the production of wheat more especially, it is only by the accumulation within the soil itself of nitrogen, *naturally* derived from the atmosphere, rather than of the peculiarly soil-constituents, that our crops of it can be increased. Mineral substances will indeed materially develop the accumulation of vegetable or atmospheric constituents when applied to *some* of the crops of rotation; and it is thus chiefly that these crops become subservient to the growth of the cereal grains; but even in these cases it is not the constituents, *as found collectively in the ashes of the plants to be grown,* that are the most efficient in this respect; nor can the demand which we find thus made for the production of crops in *agricultural quantity* be accounted for by the mere idea of supplying the *actual* constituents of the crop. It would seem, therefore, that we can only arrive at correct ideas in agriculture by a close examination of the actual circumstances of growth of each particular crop when grown under cultivation. We now turn to the consideration of our experiments upon this subject.

It has been said that all the experimental fields were selected when they were in a state of agricultural exhaustion. The wheat-field, however, after having been manured in the usual way for turnips at the commencement of the previous rotation, had then grown barley, peas, wheat, and oats, without any further manuring; so that when taken for experiment in 1844, it was, as a grain-producer, considerably more exhausted than would ordinarily be the case. It was, therefore, in a most favourable condition for the purposes of our experiment.

In the first experimental season, the field of 14 acres was divided into about 20 plots, and it was by the *mineral theory* that we were mainly guided in the selection of manures; mineral manures were therefore employed in the majority of cases. *Ammonia,* on the other hand, being then considered as of less importance, was used in a few instances only, and in these in very insignificant quantities. Rape-cake, as being a well-recognised manure, and calculated to supply—besides some minerals and nitrogen—a certain quantity of *carbonaceous* substance in which both corn and straw so much abound, was also added to one or two of the plots.

The results of this first season (1844) having already been pretty fully detailed in this Journal, we can only give a summary of them in this place:—

TABLE I.*

Harvest 1844. Summary. (See first section of diagram I., opposite p. 14.)

Description of the Manures.	Dressed Corn per Acre, in Bushels and Pecks.		Total Corn per Acre, in lbs.	Straw per Acre, in lbs.
	bush.	pecks.	lbs.	lbs.
Plot 3. Unmanured	16	0	923	1120
,, 2. 14 tons of farm-yard manure . .	22	0	1276	1476
,, 4. The ashes of 14 tons of farm-yard manure.	16	0	888	1104
,, 8. *Minimum* produce of 9 plots with artificial mineral manures:— Superphosphate lime 350 lbs. Phosphate of potass 364 lbs.	16	1	980	1160
,, 15. *Maximum* produce of 9 plots with artificial mineral manures:— Superphosphate lime 350 lbs. Phosphate magnesia 168 lbs. Phosphate potass 150 lbs. Silicate potass 112 lbs.	17	3¼	1096	1240
Mean of the 9 plots with artificial mineral manures	16	3¾	1009	1155
Mean of 3 plots with mineral manures and 65 lbs. each of sulphate ammonia	21	0	1275	1423
Mean of 2 plots with mineral manures and 150 lbs. and 300 lbs. of rape-cake respectively . .	18	1¾	1078	1201
Plot 18. With complex mineral manure, 65 lbs. of sulphate of ammonia, and 150 lbs. of rape-cake	22	3¼	1368	1768

The indications of the table are seen to be most conclusive, as showing what was the character of the exhaustion which had been induced by the previous heavy cropping, and what, therefore, should be the peculiar nature of the supply in a rational system of manuring. If the exhaustion had been connected with a deficiency of mineral constituents, we might reasonably have expected that by some one at least of the nine mineral conditions—supplying in some cases an abundance of every mineral constituent which the plant could require—this deficiency would have been made up; but it was not so.

* It should be stated that the terms Superphosphate of Lime, Phosphate of Potass, Phosphate of Soda, and Phosphate of Magnesia, as used in this and the following Tables, and by which it is convenient to designate the manures, are not to be understood as representing the chemical substances bearing those names. They were formed by acting upon burnt bone-dust by means of sulphuric acid in the first instance, and in the cases of the alkaline salts and the magnesian one by neutralizing the compound thus obtained by means of cheap preparations of the respective bases. The Silicate of Potass was manufactured at a glass-house by fusing equal parts of pearlash and sand—a transparent glass, slightly deliquescent in the air, was the result. It was ground to powder under edge-stones. The Sulphate and the Muriate of Ammonia were such as are usually sold for the purposes of manure, and it may be estimated that one hundredweight of them respectively is equal to 100 lbs. of the pure crystallized salt. The sulphuric acid used was of the specific gravity of about 1·7.

Thus, taking the column of bushels per acre as given in this summary, as our guide, it will be seen that whilst we have without manure only 16 bushels of dressed corn, we have by farm-yard manure 22 bushels. The *ashes* of farm-yard manure give, however, no increase whatever over the unmanured plot. Again, out of the 9 plots supplied with artificial mineral manures, we have in no case an increase of 2 bushels by this means; the produce of the average of the 9 being not quite 17 bushels. On the other hand, we see that the addition to some of these purely mineral manures of 65 lbs. of sulphate of ammonia—a very small dressing of that substance, and containing only about 14 lbs. of ammonia—has given us an average produce of 21 bushels. An insignificant addition of rape-cake too, to manures otherwise ineffective, has given us about 18½ bushels; and when, as in plot 18, we have added to the inefficient mineral manures 65 lbs. of ammoniacal salts, and a little rape-cake also, we have a produce greater than by the 14 tons of farm-yard manure.

The quantities of rape-cake used were small, and the increase attributable to it also small, but it nevertheless was much what we should expect when compared with that from the ammoniacal salts, if, as we believe is the case, the effect of rape-cake on *grain-crops* is due to the nitrogen it contains.

Indeed, the coincidence in the slight or non-effect throughout the mineral series on the one hand, and of the marked and nearly uniform result of the nitrogenous supply on the other, was most striking in the first year's experimental produce, and such as to lead us to give to nitrogenous manures in the second season even greater prominence than we had done to minerals in the previous one. This is in some respects, perhaps, to be regretted, as had we kept a series of plots for some years continuously under minerals alone, the evidence, though at present sufficiently conclusive, would have carried with it somewhat more of *systematic* proof.

In Table II. (see following page) we have given a few results selected from those obtained at the harvest of 1845, the second of the experimental series. By the table it is seen that we have, at the harvest of 1845, a produce of rather more than 23 bushels without manure of any kind, instead of only 16 as in 1844; and in like manner the farm-yard manure gives 32 bushels in 1845, and only 22 in 1844. We have shown in a former number of the Journal how clearly these differences can be traced to variations in the climatic character of the *season*, but this is not the point under consideration just now.

We assume, then, 23 bushels or thereabouts to be the standard produce of the soil and season, without manure, during this second experimental year; and as part of plot 5 (previously manured

TABLE II.

Harvest 1845. Selected Results. (See second section of diagram I., opposite p. 14.)

Description and Quantities of the Manures per Acre.	Dressed Corn per Acre, in Bushels and Pecks.		Total Corn per Acre, in lbs.	Straw per Acre, in lbs.
	bush.	pecks.	lbs.	lbs.
Section 1.				
Plot 3. No manure	23	$0\frac{3}{4}$	1441	2712
,, 2. 14 tons of farm-yard manure	32	$0\frac{1}{2}$	1967	3915
Section 2.				
,, 5*a*. No manure	22	$2\frac{1}{4}$	1431	2684
,, 5*b*. Top-dressed with 252 lbs. of carbonate ammonia (dissolved), at 3 times, during the spring	26	$3\frac{3}{4}$	1732	3599
Section 3.				
,, 9. Sulphate of ammonia 168 lbs. Muriate of ammonia 168 lbs. top-dressed at once	33	$1\frac{1}{2}$	2131	4058
,, 10. Sulphate of ammonia 168 lbs. Muriate of ammonia 168 lbs. top-dressed at 4 times	31	$3\frac{1}{4}$	1980	4266

with superphosphate of lime), and which is now, also, without manure, gives rather more than $22\frac{1}{2}$ bushels of dressed corn, the correctness of the result of plot 3, the permanently unmanured plot, is thereby fully confirmed.

This plot No. 5, previously two-thirds of an acre, was, in this second year, divided into two equal portions; one of these ("plot 5*a*") being, as just said, unmanured, and the other ("plot 5*b*") having supplied to it in solution, by top-dressings during the spring, the *medicinal carbonate of ammonia,* at the rate of 250 lbs. per acre: and it is seen that we have, by this pure but highly volatile ammoniacal salt alone, the produce raised from $22\frac{1}{2}$ bushels to very nearly 27 bushels!

In the next section of the table are given the results of plots 9 and 10, the former of which had in the previous year been manured by superphosphate of lime and a small quantity of sulphate of ammonia, and the latter by superphosphate of lime and silicate of potass. To each of these plots $1\frac{1}{2}$ cwt. of sulphate and $1\frac{1}{2}$ cwt. of muriate of ammonia were now supplied. Upon plot 9 the whole of the manure was top-dressed, *at once,* early in the spring; but on plot 10 the salts were put on at four successive periods. The produce obtained by these salts of ammonia alone is 33 bushels and three-eighths, when sown all at once, and nearly 32 bushels when sown at four different times—quantities which amount to about 10 bushels per acre more than was obtained

without manure. In the case of No. 9, indeed, the produce exceeds by 1¼ bushel that given by farm-yard manure, and in that of No. 10 it is all but identical with it. And if we take the weights of total corn, instead of the *measure* of the dressed corn, to which latter we chiefly refer, merely as a standard more conventionally understood, No. 10, by ammonia only, has given both more corn and more straw than the farm-yard manure, with all its minerals and carbonaceous substance.

Let us see whether this almost specific effect of nitrogen, in restoring, for the reproduction of corn, a corn-exhausted soil, is borne out by the results of succeeding years.

In relation to the third experimental year (harvest 1846), we have already given in a tabular form in our former article most of the results; but for want of time and space the attention of the reader was specially called to one or two of them only. We shall, therefore, on this occasion offer a few remarks on some of those not previously discussed; and we should have omitted all reference to the results obtained with the wheat manure of Professor Liebig, to which we have already called attention, had not the Professor, in the new edition of his 'Letters,' whilst fully admitting the failure of the manure—the composition of which, to use his own words when commenting upon it, "could be no secret, since every plant showed by its ashes the due proportion of the constituents essential to its growth" (page 482),—not expressed any doubt as to the principle involved in such a manure, but, on the other hand, implied that the failure was due to a yet imperfect knowledge of the mechanical form and chemical qualities required to be given to the necessary constituents in order to fit them for their reception and nutritive action on the plant, rather than to any fallacy in the theory which would recommend to practical agriculture the supply by artificial means of the constituents of the ashes of plants as manures.

We do not mean to say that Liebig's manure was not at fault as to its mechanical form and chemical qualities, and *from their failure* the same might, perhaps, be said of all the mineral mixtures employed in our experiments. We must be careful, however, not to rely upon an argument of this kind without sufficient ground, for it must be observed that in this way every negative result of experiment whatever might be held as showing nothing, and indeed that every positive one was equally little to be trusted; for it might be said that had we managed better, the one which is now negative might have been the most successful, and thus experiments of any kind would be at an end, and useless.

But to return to the experiments. The following table gives our selection of the results of the third season, 1846:—

TABLE III.

Harvest 1846. Selected Results. (See third section of diagram I., opposite p. 14.)

Description and Quantities of the Manures per Acre.	Dressed Corn per Acre, in Bushels and Pecks.		Total Corn per Acre, in lbs.	Straw per Acre, in lbs.
	bush.	pecks.	lbs.	lbs.
Section 1.				
Plot 3. No manure	17	3¾	1207	1513
,, 2. 14 tons of farm-yard manure	27	0¾	1826	2454
Section 2.				
,, 10*b*. No manure	17	2½	1216	1455
,, 10*a*. Sulphate of ammonia 224 lbs.	27	1½	1850	2244
Section 3.				
,, 5*a*¹. Ash of 3 loads of wheat straw	19	0½	..	1541
,, 5*a*². Ash of 3 loads of wheat straw, and top-dressed with 224 lbs. of sulphate of ammonia	27	0	..	2309
Section 4.				
,, 6*a*. Liebig's wheat manure 448 lbs.	20	1½	1400	1676
,, 6*b*. Liebig's wheat manure 448 lbs., with 112 lbs. each of sulphate and muriate of ammonia	29	0¾	1967	2571

At this third experimental harvest we have on the continuously unmanured plot, namely, No. 3, not quite 18 bushels of dressed corn, as the normal produce of the season; and by its side we have on plot 10*b*,—comprising one-half of the plot 10 of the previous years, and so highly manured by ammoniacal salts in 1845, but now unmanured,—rather more than 17½ bushels. The near approach, again, to identity of result from the two unmanured plots, at once gives confidence in the accuracy of the experiments, and shows us how effectually the preceding crop had, in a practical point of view, reduced the plots, previously so differently circumstanced both as to manure and produce, to something like an uniform standard as regards their grain-producing qualities. We take this opportunity of particularly calling attention to these coincidences in the amount of produce in the two unmanured plots of the different years, because it has been objected against our experiments, as already published, that confirmation was wanting as to the natural yield of soil and season.

Plot 2 has, as before, 14 tons of farm-yard manure, and the produce is 27¼ bushels, or between 9 and 10 bushels more than without manure of any kind.

On plot 10*a*, which in the previous year gave by ammoniacal

salts alone a produce equal to that of the farm-yard manure, we have again a similar result: for 2 cwts. of sulphate of ammonia has now given 1850 lbs. of total corn, instead of 1826 lbs., which is the produce on plot 2. The straw of the latter is, however, slightly heavier than that by the ammoniacal salt.

Again, plot 5*a*, which was in the previous season *unmanured*, was now subdivided: on one half of it (namely, $5a^1$) we have the ashes of wheat-straw alone, by which there is an increase of rather more than 1 bushel per acre of dressed corn; on the other half (or $5a^2$) we have, besides the straw ashes, 2 cwts. of sulphate of ammonia put on as a top-dressing: 2 cwts. of sulphate of ammonia have, in this case, only increased the produce beyond that of $5a^1$ by $7\frac{7}{8}$ bushels of corn and 768 lbs. of straw, instead of by $9\frac{6}{8}$ bushels of corn and 789 lbs. of straw, which was the increase obtained by the same amount of ammoniacal salt on 10 *a*, as compared with 10 *b*. It will be observed, however, that in the former case the ammoniacal salts were top-dressed, but in the latter they were drilled at the time of sowing the seed; and it will be remembered that in 1845 the result was better *as to corn* on plot 9, where the salts were sown earlier, than on plot 10, where the top-dressing extended far into the spring. We have had several direct instances of this kind in our experience, and we would give it as a suggestion, in most cases applicable, that manures for wheat, and especially ammoniacal ones, should be applied before or at the time the seed is sown; for, although the apparent luxuriance of the crop is greater, and the produce of straw really heavier, by spring rather than autumn sowings of Peruvian guano and other ammoniacal manures, yet we believe that that of the *corn* will not be increased in an equivalent degree. Indeed, the success of the crop undoubtedly depends very materially on the progress of the underground growth during the winter months; and this again, other things being equal, upon the quantity of available nitrogenous constituents within the soil, without a liberal provision of which, the range of the fibrous feeders of the plant will not be such, as to take up the minerals which the soil is competent to supply, and in such quantity as will be required during the after progress of the plant for its healthy and favourable growth.

The next result to be noticed is that obtained on plot 6, now also divided into two equal portions designated respectively 6*a* and 6*b*. Plot No. 6 had for the crop of 1844 superphosphate of lime and the phosphate of magnesia manure, and for that of 1845 superphosphate of lime, rape-cake, and ammoniacal salts. For this, the third experimental season, it was devoted to the trial of the wheat manure manufactured under the sanction of Professor Liebig, and patented in this country.

Upon plot 6*a*, 4 cwts. per acre of the patent wheat-manure were

used, which gave $20\frac{1}{4}$ bushels, or rather more than 2 bushels beyond the produce of the unmanured plot; but as the manure contained, besides the minerals peculiar to it, some nitrogenous compounds, giving off a very perceptible odour of ammonia, some, at least, of the increase would be due to that substance. On plot 6*b*, however, the further addition of 1 cwt. each of sulphate and muriate of ammonia to this so-called "Mineral Manure," gives a produce of $29\frac{1}{4}$ bushels. In other words, the addition of ammoniacal salt to Liebig's mineral manure has increased the produce by very nearly 9 bushels per acre beyond that of the mineral manure alone, whilst the increase obtained over the unmanured plot, by 14 tons of farm-yard manure, was only $9\frac{1}{4}$ bushels!

If, then, the "mechanical form and chemical qualities" of the so-called "Mineral Manure" were at fault, the sulphate of ammonia has, at least, compensated for the defect; and even supposing a mineral manure, founded on a knowledge of the composition of the ashes of the plant, be still the great desideratum, the farmer may rest contented, meanwhile, that he has in ammonia, supplied to him by Peruvian guano, by ammoniacal salts, and by other sources, so good a substitute.

In Table IV. are one or two of the results of the harvest of 1847, which bear upon our question.

TABLE IV.

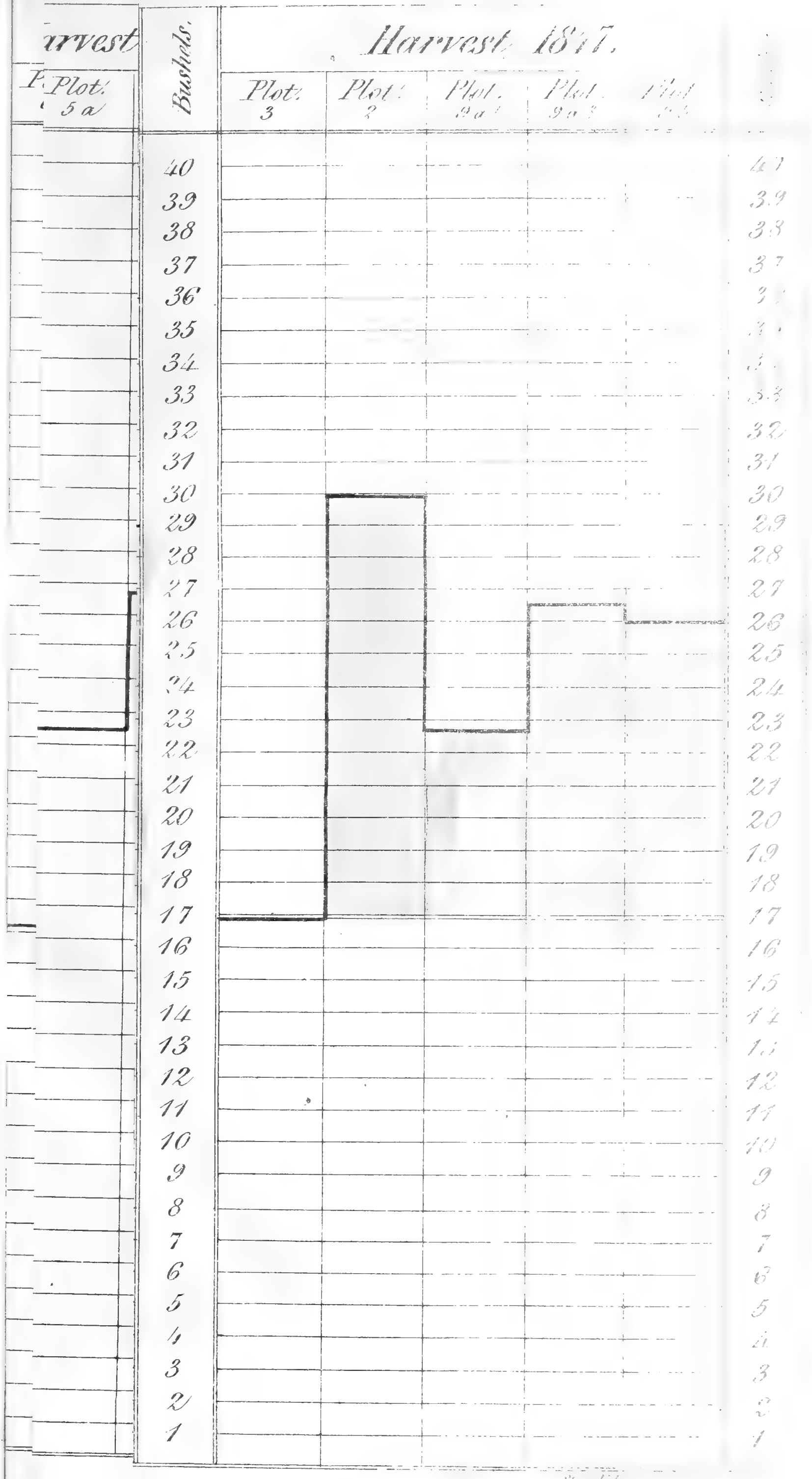
Harvest 1847. Selected Results. (See fourth section of diagram I., opposite p. 14.)

Description and Quantities of the Manures per Acre.	Dressed Corn per Acre, in Bushels and Pecks.		Total Corn per Acre, in lbs.	Straw per Acre, in lbs.
	bush.	pecks.	lbs.	lbs.
Section 1.				
Plot 3. No manure	16	$3\frac{1}{2}$	1123	1902
,, 2. 14 tons of farm-yard manure . . .	29	$3\frac{3}{4}$	1981	3628
Section 2.				
,, 9*a*¹. 1 ton of Rice	22	3		
,, 9*a*². { Sulphate of ammonia 150 lbs. / Muriate of ammonia 150 lbs. } . .	26	2		
,, 9*b*. { Sulphate of ammonia 150 lbs. / Muriate of ammonia 150 lbs. } . .	26	0		

The produce of the continuously unmanured plot is now seen to be almost 17 bushels of dressed corn, and that of the plot with farm-yard manure nearly 30 bushels.

Plots 9*a* and 9*b*, the former of which had in the previous season 4 cwts. of rape-cake, and the latter 4 cwts. of rape-cake and

3,10,1



arvest
Plot 5 a
Bushels
Harvest 1847.
Plot 3
Plot 2
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DIAGRAM 1. Showing the results, as to Dressed Corn, given in Tables 1, 2, 3 & 4 at pages 8, 10, 12 and 14 respectively.

NOTE *This and the following Diagram were not contemplated until after the paper itself had been printed & hence there is no reference to them in the text. But it is thought that a clearer conception of the results of the Wheat experiments will be conveyed, if presented in this form. The produce of dressed Corn only is represented, though it would have been useful to have given on a similar plan, that of the Straw also, had there been time to do so.*

Explanation of Diagram I.

In this Diagram are presented to view the selected results of the Harvests 1844 5, 6 & 7 which have been discussed in the paper & which are given or referred to, in Tables 1, 2, 3 & 4.

As will be seen the divisions marked out by the horizontal lines indicate bushels and each Column an individual Plot the Number of which is given in its heading.

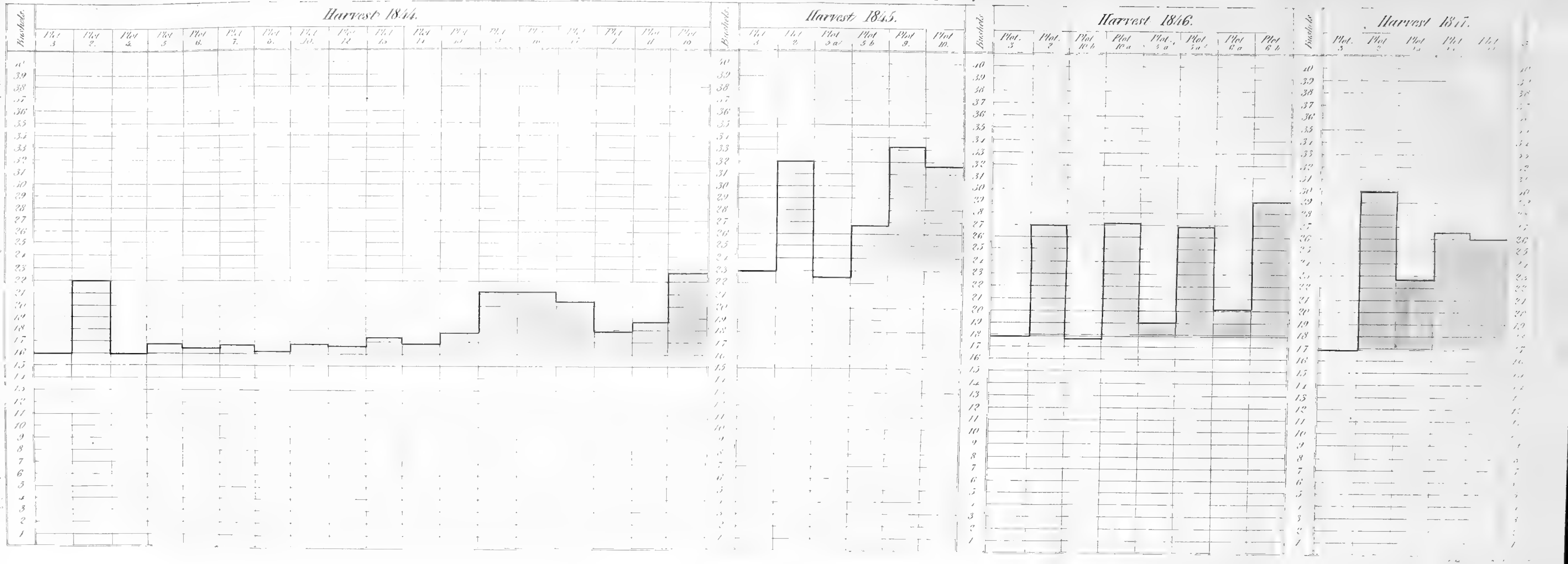
The lower uncolored portion of the Columns represents the amount of produce on the number 3 Plot, without manure.

The colored portions represent the increase by the different manures; each color indicating a particular kind of manure, thus

Blank	*Unmanured*
Grey	*Farm Yard manure.*
Blue	*Mineral manure only*
Red	*Ammoniacal Salt only*
Purple	*Vegetable matter Supplying Carbon &c. (Rice)*
Yellow	*Minerals & Ammoniacal Salt*
Green	*Minerals & Vegetable matter, supplying carbon &c., rapecake*
Brown	*Minerals Rapecake & Ammoniacal Salt*

In the Year 1845, Plot 5 a, without manure gives a produce less than that of Plot 3, the continuously unmanured Plot. This is indicated by the Black line descending below the Standard unmanured level of the Season.

And again in 1846 the produce of Plot 10 b without manure is less than that of Plot 3 & this result is similarly represented.



2 cwts. of sulphate of ammonia, with no direct mineral manure in either case since the first season of 1844, were in this, the fourth season, set apart for the trial of some substance rich in *carbon* (but not so either in nitrogen or in mineral matter), by the side of pure nitrogenous supply. Thus one half of $9a$ ($9a^1$) was manured with *ground rice*, at the rate of 1 ton to the acre. The other half of $9a$ ($9a^2$) had 150 lbs. of sulphate and 150 lbs. of muriate of ammonia; as also had $9b$. The effect of the 1 ton of rice is to give 22¾ bushels of dressed corn, or only 6 bushels more than the unmanured plot; whilst the ammoniacal salts of $9a^2$ and $9b$ gave respectively 26½ and 26 bushels. That is to say, with a difference of only half a bushel in the two cases with ammoniacal salts, an average is obtained of 9½ bushels more than on the unmanured plot.

It surely is needless to attempt further to justify, by the results of individual years, our assertion, that in practical agriculture nitrogenous manures are peculiarly adapted to the growth of wheat. We shall therefore conclude this part of our subject by directing attention to the history of a few of the plots throughout the entire series of years up to the present time, as compared with that of the unmanured plot during the same period.

The six next tables which follow (numbered V. to X. inclusive) give the results of 6 of the plots thus compared with the unmanured one; and in Table XI. we have the results of all those plots brought together in one view.

TABLE V.

Showing the Results of Plot 10*a* compared with those of the Unmanured Plot. (See first section of diagram II., opposite p. 28.)

Harvest.	Description of the Manures of Plot 10*a*.; the yield of which stands in the *second* column.	Section 1. Actual produce per Acre. Dressed Corn, in Bushels and Pecks.		Total Corn, in lbs.		Straw, in lbs.		Section 2. Increase per Acre by Manure.		
		Plot 3. Un-manured.	Plot 10*a*.	Plot 3. Un-manured.	Plot 10*a*.	Plot 3. Un-manured	Plot 10*a*.	Dressed Corn, in Bushels and Pecks.	Total Corn, in lbs.	Straw, in lbs.
		bush. pks.	bush. pks.	lbs.	lbs.	lbs.	lbs.	bush. pks.	lbs.	lbs.
1844	Superphosphate of Lime 560 lbs., and Silicate of Potass 220 lbs.	16 0	16 3¾	923	1008	1120	1112	0 3¾	85	−8
1845	Sulphate of Ammonia 168 lbs., and Muriate of Ammonia 168 lbs., top-dressed at 4 times	23 0¾	31 3¼	1441	1980	2712	4266	8 2½	539	1554
1846	Sulphate of Ammonia 224 lbs.	17 3¾	27 1½	1207	1850	1513	2244	9 1¾	643	731
1847	Sulphate of Ammonia 150 lbs., and Muriate of Ammonia 150 lbs.	16 3½	25 3	1123	1702	1902	2891	8 3½	579	989
1848	Sulphate of Ammonia 150 lbs., and Muriate of Ammonia 150 lbs.	14 3	19 1	952	1334	1712	2367	4 2	382	655
1849	Sulphate of Ammonia 200 lbs., and Muriate of Ammonia 200 lbs.	19 1	32 2	1227	2141	1614	2854	13 1	914	1240
1850	Sulphate of Ammonia 200 lbs., and Muriate of Ammonia 200 lbs.	15 3¼	26 3½	1000	1721	1719	3089	11 0¼	721	1370
	Totals	123 3¼	180 2	7873	11,736	12,292	18,823	56 2¾	3863	6531
	Mean per Annum. .	17 2¾	25 3¼	1125	1676	1756	2689	8 0½	552	933

TABLE VI.

Showing the Results of Plot 10*b* compared with those of the Unmanured Plot. (See second section of diagram II., opposite p. 28.)

Harvest.	Description of the Manures of Plot 10*b*.; the yield of which stands in the *second* column.	Section 1. Actual produce per Acre. Dressed Corn, in Bushels and Pecks. Plot 3. Un-manured.	Section 1. Dressed Corn, Plot 10*b*.	Section 1. Total Corn, in lbs. Plot 3. Un-manured.	Section 1. Total Corn, Plot 10*b*.	Section 1. Straw, in lbs. Plot 3. Un-manured.	Section 1. Straw, Plot 10*b*.	Section 2. Increase per Acre by Manure. Dressed Corn, in Bushels and Pecks.	Section 2. Total Corn, in lbs.	Section 2. Straw, in lbs.
		bush. pks.	bush. pks.	lbs.	lbs.	lbs.	lbs.	bush. pks.	lbs.	lbs.
1844	Superphosphate of Lime 560 lbs., and Silicate of Potass 220 lbs.	16 0	16 3¾	923	1008	1120	1112	0 3¾	85	−8
1845	Sulphate of Ammonia 168 lbs., and Muriate of Ammonia 168 lbs., top-dressed at 4 times	23 0¾	31 3¼	1441	1980	2712	4266	8 2½	539	1554
1846	No Manure	17 3¾	17 2½	1207	1216	1513	1455	−0 1¼	9	−58
1847	Sulphate of Ammonia 150 lbs., and Muriate of Ammonia 150 lbs.	16 3½	25 2¾	1123	1705	1902	2874	8 3¼	582	972
1848	Pearlash 300 lbs., Soda-ash 200 lbs., and Sulphate of Magnesia 100 lbs., Calcined Bone-dust 200 lbs., Sulphuric Acid 150 lbs., and 150 lbs. each of Sulphate and Muriate of Ammonia	14 3	25 0¼	952	1604	1712	2926	10 1¼	652	1214
1849	Sulphate of Ammonia 200 lbs., and Muriate of Ammonia 200 lbs.	19 1	32 2¾	1227	2156	1614	2964	13 1¾	929	1350
1850	Pearlash 300 lbs., Soda-ash 200 lbs., and Sulphate of Magnesia 100 lbs., Bone Ash 200 lbs., and Sulphuric Acid 150 lbs.	15 3¼	17 3¾	1000	1171	1719	1949	2 0½	171	104
	Totals	123 3¼	167 3	7873	10,840	12,292	17,546	43 3¾	2967	5128
	Mean per Annum . .	17 2¾	23 3¾	1125	1548	1756	2507	6 1	424	733

Table VII.

Showing the Results of Plot 18*a* compared with those of the Unmanured Plot. (See third section of diagram II., opposite p. 28.)

Harvest.	Description of the Manures of Plot 18*a*.; the yield of which stands in the *second* column.	Section 1. Actual produce per Acre. Dressed Corn, in Bushels and Pecks. Plot 3. Unmanured.		Section 1. Dressed Corn, in Bushels and Pecks. Plot 18*a*.		Section 1. Total Corn, in lbs. Plot 3. Unmanured.	Section 1. Total Corn, in lbs. Plot 18*a*.	Section 1. Straw, in lbs. Plot 3. Unmanured.	Section 1. Straw, in lbs. Plot 18*a*.	Section 2. Increase per Acre by Manure. Dressed Corn, in Bushels and Pecks.		Section 2. Total Corn, in lbs.	Section 2. Straw, in lbs.
		bush.	pks.	bush.	pks.	lbs.	lbs.	lbs.	lbs.	bush.	pks.	lbs.	lbs.
1844	350 lbs. Superphosphate of Lime, 84 lbs. Phosphate of Magnesia, 65 lbs. of Phosphate of Soda, 75 lbs. Phosphate of Potass, 112 lbs. Silicate of Potass, 65 lbs. Sulphate of Ammonia, 154 lbs. of Rape Cake	16	0	22	3¼	923	1368	1120	1768	6	3¼	445	648
1845	336 lbs. Superphosphate of Lime, and 112 lbs. each of Sulphate and Muriate of Ammonia	23	0¾	33	0¼	1441	2048	2712	3819	9	3½	607	1107
1846	224 lbs. Calcined Bone-dust, 224 lbs. Sulphuric Acid, 60 lbs. Soda Ash, 67 lbs. Pearlash, and 84 lbs. Magnesian Limestone; and 112 lbs. each of Sulphate and Muriate of Ammonia	17	3¾	31	0	1207	2048	1513	2838	13	0¼	841	1325
1847	100 lbs. Calcined Bone-dust, 100 lbs. Sulphuric Acid, and 150 lbs. each of Sulphate and Muriate of Ammonia	16	3½	32	0¾	1123	2160	1902	3852	15	1¼	1037	1950
1848	300 lbs. Pearlash, 200 lbs. Soda Ash, 100 lbs. Sulphate of Magnesia, 200 lbs. Calcined Bone-dust, 150 lbs. Sulphuric Acid, and 150 lbs. each of Sulphate and Muriate of Ammonia	14	3	26	3	952	1734	1712	2935	12	0	782	1223
1849	300 lbs. Pearlash, 200 lbs. Soda Ash, 100 lbs. Sulphate of Magnesia, 200 lbs. Calcined Bone-dust, 150 lbs. Sulphuric Acid, and 200 lbs. each of Sulphate and Muriate of Ammonia	19	1	32	1½	1227	2162	1614	3592	13	0½	935	1978
1850	300 lbs. Pearlash, 200 lbs. Soda Ash, 100 lbs. Sulphate of Magnesia, 200 lbs. Bone-ash, 150 lbs. Sulphuric Acid, and 200 lbs. each of Sulphate and Muriate of Ammonia	15	3¼	29	3	1000	1934	1719	3927	13	3¾	934	1208
	Totals	123	3¼	207	3¾	7873	13,454	12,292	22,731	84	0½	5581	9439
	Mean per Annum	17	2¾	29	2¾	1125	1922	1756	3247	12	0	797	1348

TABLE VIII.

Showing the Results of Plot 18*b* compared with those of the Unmanured Plot. (See fourth section of diagram II., opposite p. 28.)

Harvest.	Description of the Manures of Plot 18*b*.; the yield of which stands in the *second* column.	Section 1. Actual produce per Acre. Dressed Corn, in Bushels and Pecks. Plot 3. Unmanured.		Section 1. Dressed Corn, Plot 18*b*.		Total Corn, in lbs. Plot 3. Unmanured.	Total Corn, Plot 18*b*.	Straw, in lbs. Plot 3. Unmanured.	Straw, Plot 18*b*.	Section 2. Increase per Acre by Manure. Dressed Corn, in Bushels and Pecks.		Total Corn, in lbs.	Straw, in lbs.
		bush.	pks.	bush.	pks.	lbs.	lbs.	lbs.	lbs.	bush.	pks.	lbs.	lbs.
1844	350 lbs. Superphosphate of Lime, 84 lbs. Phosphate of Magnesia, 65 lbs. Phosphate of Soda, 75 lbs. Phosphate of Potass, 65 lbs. Sulphate of Ammonia, 112 lbs. Silicate of Potass, 154 lbs. of Rape-cake	16	0	22	3¼	923	1368	1120	1768	6	3¼	445	648
1845	336 lbs. Superphosphate of Lime, 112 lbs. each of Sulphate and Muriate of Ammonia	23	0¾	33	0¼	1441	2048	2712	3819	9	3½	607	1107
1846	224 lbs. Calcined Bone-dust, 224 lbs. Sulphuric Acid, 60 lbs. Soda Ash, 67 lbs. Pearlash, and 84 lbs. Magnesian Limestone	17	3¾	21	1	1207	1474	1513	1893	3	1¼	267	380
1847	100 lbs. Calcined Bone-dust, 100 lbs. Sulphuric Acid, and 150 lbs. each of Sulphate and Muriate of Ammonia	16	3½	29	1½	1123	2029	1902	4164	12	2	906	2262
1848	300 lbs. Pearlash, 200 lbs. Soda Ash, 100 lbs. Sulphate of Magnesia, 200 lbs. Calcined Bone-dust, 150 lbs. Sulphuric Acid, and 150 lbs. each of Sulphate and Muriate of Ammonia	14	3	26	2¾	952	1804	1712	3056	11	3¾	852	1344
1849	300 lbs. Pearlash, 200 lbs. Soda Ash, 100 lbs. Sulphate of Magnesia, 200 lbs. Calcined Bone-dust, 150 lbs. Sulphuric Acid, and 200 lbs. each of Sulphate and Muriate of Ammonia	19	1	33	2¼	1227	2242	1614	3778	14	1¼	1015	2164
1850	300 lbs. Pearlash, 200 lbs. Soda Ash, 100 lbs. Sulphate of Magnesia, 200 lbs. Bone-ash, 150 lbs. Sulphuric Acid, and 200 lbs. each of Sulphate and Muriate of Ammonia	15	3¼	28	2½	1000	1845	1719	3843	12	3¼	845	2124
	Totals	123	3¼	195	1½	7873	12,810	12,292	22,321	71	2¼	4937	10,029
	Mean per Annum	17	2¾	27	3½	1125	1830	1756	3189	10	1	705	1433

Table IX.

Showing the Results of Plot 17*b*, compared with those of the Unmanured Plot. (See fifth section of diagram II., opposite p. 28.)

Harvest.	Description of the Manures of Plot 17*b*.; the yield of which stands in the *second* column.	Section 1. Actual produce per Acre.								Section 2. Increase per Acre by Manure.			
		Dressed Corn, in Bushels and Pecks.				Total Corn, in lbs.		Straw, in lbs.		Dressed Corn, in Bushels and Pecks.		Total Corn, in lbs.	Straw, in lbs.
		Plot 3. Un-manured.		Plot 17*b*.		Plot 3. Un-manured.	Plot 17*b*.	Plot 3. Un-manured.	Plot 17*b*.				
		bush.	pks.	bush.	pks.	lbs.	lbs.	lbs.	lbs.	bush.	pks.	lbs.	lbs.
1844	350 lbs. Superphosphate of Lime, 84 lbs. Phosphate of Magnesia, 65 lbs. Phosphate of Soda, 75 lbs. Phosphate of Potass, 112 lbs. Silicate of Potass, and 65 lbs. Sulphate of Ammonia	16	0	20	2¼	923	1240	1120	1422	4	2¼	371	302
1845	224 lbs. Superphosphate of Lime, 280 lbs. Rape-cake, and 112 lbs. each of Sulphate and Muriate of Ammonia	23	0¾	32	0¾	1441	2093	2712	3826	9	0	652	1114
1846	224 lbs. each of Calcined Bone-dust and Sulphuric Acid, 60 lbs. Soda Ash, 67 lbs. Pearlash, 84 lbs. Magnesian Limestone, and 224 lbs. Sulphate of Ammonia	17	3¾	30	2	1207	2034	1513	2784	12	2¼	827	1271
1847	100 lbs. each of Calcined Bone-dust and Sulphuric Acid, and 200 lbs. each of Sulphate and Muriate Ammonia	16	3½	35	1¾	1123	2314	1902	4261	13	2¼	1191	2359
1848	300 lbs. Pearlash, 200 lbs. Soda Ash, 100 lbs. Sulphate of Magnesia, 200 lbs. Calcined Bone-dust, 150 lbs. Sulphuric Acid, and 200 lbs. each of Sulphate and Muriate of Ammonia	14	3	28	3½	952	1946	1712	3324	14	0½	994	1612
1849	300 lbs. Pearlash, 200 lbs. Soda Ash, 100 lbs. Sulphate of Magnesia, 200 lbs. Calcined Bone-dust, 150 lbs. Sulphuric Acid, and 200 lbs. each of Sulphate and Muriate of Ammonia	19	1	33	1½	1227	2257	1614	3858	14	0½	1030	2244
1850	300 lbs. Pearlash, 200 lbs. Soda Ash, 100 lbs. Sulphate of Magnesia, 200 lbs. Bone-ash, 150 lbs. Sulphuric Acid, and 200 lbs. each of Sulphate and Muriate of Ammonia	15	3¼	29	2¼	1000	1960	1719	4034	13	3	960	2315
	Totals	123	3½	210	2	7873	13,844	12,292	23,529	86	2¾	6025	11,217
	Mean per Annum	17	2¾	30	0¼	1125	1978	1756	3361	12	1½	861	1602

Table X.

Showing the Results of Plot 2, compared with those of the Unmanured Plot. (See sixth section of diagram II., opposite p. 28.)

Harvests,	Section 1. Actual Produce per Acre.								Section 2. Increase per Acre by Manure.				Section 3. Increase per Cent, over the Unmanured Plot.		
	Dressed Corn, in Bushels and Pecks.				Total Corn, in lbs.		Straw, in lbs.								
	Plot 3. Un-manured.		Plot 2. 14 Tons of Farm-yard Manure every Year.		Plot 3. Un-manured.	Plot 2. 14 Tons of Farm-yard Manure every Year.	Plot 3. Un-manured.	Plot 2. 14 Tons of Farm-yard Manure every Year.	Dressed Corn, in Bushels and Pecks.		Total Corn, in lbs.	Straw, in lbs.	Dressed Corn.	Total Corn.	Straw.
	bush.	pks.	bush.	pks.	lbs.	lbs.	lbs.	lbs.	bush.	pks.	lbs.	lbs.			
1844	16	0	22	0	923	1267	1120	1476	6	0	355	356	37·5	38·2	31·8
1845	23	0¾	32	0½	1441	1967	2712	3915	8	3¾	526	1203	38·5	36·5	44·4
1846	17	3¾	27	0¾	1207	1826	1513	2454	9	1	619	941	51·6	51·3	62·2
1847	16	3½	29	3¾	1123	1981	1902	3628	13	0¼	858	1726	77·4	76·4	90·7
1848	14	3	25	2¾	952	1705	1712	3041	10	3¾	753	1329	73·7	79·1	77·6
1849	19	1	30	3	1227	2053	1614	3005	11	2	826	1391	59·7	67·3	86·2
1850	15	3¼	28	2½	1000	1861	1719	3245	12	3¼	861	1526	81·4	86·1	88·8
Totals . . .	123	3¾	196	1¼	7873	12,669	12,292	20,764	72	2	4798	8472			
Mean per Annum	17	2¾	28	0¼	1125	1809	1756	2966	10	1½	685	1210	60·0	62·1	68·8

TABLE XI.

SUMMARY.—Showing the Results of Plots 10*a* and 10*b*, 18*a* and 18*b*, 17*b*, and 2, with those of the Unmanured Plot.

Section 1. Dressed Corn per Acre, in Bushels and Pecks.

Harvests	Plot 3. Unmanured		Plot 10*a*.		Plot 10*b*.		Plot 18*a*.		Plot 18*b*.		Plot 17*b*.		Plot 2.	
	bh.	pk.	bh.	pk.	bh.	pk.	bh.	pk.	bh.	pk.	bh.	pk.	bh.	pk.
1844	16	0	16	3¾	16	3¾	22	3¼	22	3¼	20	2¼	22	0
1845	23	0½	31	3¼	31	3¼	33	0¼	33	0¼	32	0¾	32	0½
1846	17	3¾	27	1½	17	2½	31	0	21	1	30	2	27	0¾
1847	16	3½	25	3	25	2¾	32	0¾	29	1½	35	1¾	29	3½
1848	14	3	19	1	25	0¼	26	3	26	2¾	28	3½	25	2¾
1849	19	1	32	2	32	2¾	32	1½	33	2¼	33	1½	30	3
1850	15	3¼	26	3½	17	3¾	29	3	28	2½	29	2¼	28	2½
Totals	123	3¼	180	2	167	3	207	3¾	195	1½	210	2	196	1¼
Mean	17	2¾	25	3¼	23	3¾	29	2¾	27	3½	30	0¼	28	0¼

Section 2. Total Corn per Acre, in lbs.

Harvests	Plot 3. Unmanured	Plot 10*a*.	Plot 10*b*.	Plot 18*a*.	Plot 18*b*.	Plot 17*b*.	Plot 2.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1844	923	1008	1008	1368	1368	1240	1267
1845	1441	1980	1980	2048	2048	2093	1967
1846	1207	1850	1216	2048	1474	2034	1826
1847	1123	1702	1705	2160	2029	2314	1981
1848	952	1334	1604	1734	1804	1946	1705
1849	1227	2141	2156	2162	2242	2257	2053
1850	1000	1721	1171	1934	1845	1960	1861
Totals	7873	11,736	10,840	13,454	12,810	13,844	12,669
Mean	1125	1776	1548	1922	1830	1978	1809

Section 3. Total Straw per Acre, in lbs.

Harvests	Plot 3. Unmanured	Plot 10*a*.	Plot 10*b*.	Plot 18*a*.	Plot 18*b*.	Plot 17*b*.	Plot 2.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1844	1120	1112	1182	1768	1768	1422	1476
1845	2712	4266	4266	3819	3819	3826	3915
1846	1513	2244	1455	2838	1893	2784	2454
1847	1902	2891	2874	3852	4164	4261	3628
1848	1712	2367	2926	2935	3056	3324	3041
1849	1614	2854	2964	3592	3778	3858	3005
1850	1719	3089	1823	3927	3843	4034	3245
Totals	12,292	18,823	17,420	22,731	22,321	23,529	20,764
Mean	1756	2689	2489	3247	3189	3361	2966

In Table V. we have compared together the produce of the unmanured plot with that of Plot 10*a*, which, excepting in 1844, when superphosphate of lime and silicate of potass were used (giving, however, less than one bushel of increase), was manured in every succeeding season by ammoniacal salts alone.

It is a remarkable fact that from Plot 3 (the unmanured one), of this previously unusually corn-exhausted soil, we have carried from the land seven successive crops of wheat grain, and of straw, without any manure whatever; and that under this treatment there are, at present, no signs of diminished fertility; for the average of the seven seasons collectively is about 17½ bushels of dressed corn, and about 16 cwts. of straw, or more than was obtained in the first experimental year. Indeed, there is little doubt that upon a soil of any given quality the produce will only vary with the character of the climate and the variations of the seasons, which must materially affect the amount of *ammonia* available from natural sources; and upon this again depends the assimilation of other constituents, which in the case of our experiments were proved to have existed in ample *relative* quantity within the reach of the plant. Thus, the results of Plot 10*a*, as seen in the 2nd column of the table, are alone sufficient to show that, whatever the deprivation by the previous cropping, the soil still contained, *relatively to the ammonia available from natural sources*, an EXCESS of the necessary mineral constituents. We shall presently show that this must be the condition of most if not all cultivated land, where *grain* and *meat* constitute—as they do, as the rule, in Great Britain—almost the exclusive exports from the farm; the straw of the grain and the excrements of the animals fed upon the farm, finding their way into the home manures, and eventually back again to the fields from whence they came.

But we must not be understood to say that all soils will yield continuously 17½ bushels of grain and 16 cwts. of straw per acre, without manure; on the contrary, we know full well that they will not, and that what are termed light soils, but which, under high cultivation, give good crops of wheat, would give but a small proportion of this quantity. That the heavier ones do possess a native fertility beyond what might at first sight be supposed, there can be little doubt; were it not so, we should find it difficult to explain how those who sell off their land almost all its produce without return, are enabled to live and pay their rent. But what we say is, that by the ordinary methods of practical agriculture, by which any soils are made to yield a fair produce of grain and meat only, for sale, their characteristic exhaustion, as grain-producers, will be that of NITROGEN; and that the mineral constituents, will, under this course, RELATIVELY TO NITROGEN, be in excess. To this point, however, we shall recur further on.

But to return to the Table (V.);—a glance will show that in *every* season the produce was greatly increased by ammoniacal salts only; and in the last two years even, when the amount of ammonia supplied was increased, so also was there a greater increase of produce obtained than in previous years; and this, notwithstanding there had been taken from the land in the previous rotation a heavy amount of minerals without return, and in the first five experimental crops the minerals, both of corn and of straw, of larger crops than are the average of the county under the ordinary system of rotation and home manuring.

The comparison afforded in Table VI. is very instructive. It gives the results of Plot 10*b*, by the side of the unmanured plot. The manuring of this Plot 10*b* was, it will be remembered, in 1844 precisely the same as that for Plot 10*a*, last under consideration; but in the succeeding years a different method of treatment was adopted. In this case, instead of giving year after year ammoniacal salts, these have been alternated with no manure, with minerals alone, and with minerals combined with ammoniacal salts, in order to ascertain how far the characteristic result of each of the conditions, thus successively provided, would in each case be developed, independently of the immediately preceding supply.

In the first year, the mineral manure gives less than one bushel increase;—in the second, ammoniacal salts give 8¾ bushels increase;—in the third season, after a heavy dressing by ammonia, and a heavy produce, the cessation of manuring reduces the produce to a trifle below that of the unmanured plot; — in the fourth year, ammoniacal salt alone increases the produce by *one half;*—in the fifth, a complex mineral manure, supplying nearly every mineral constituent of the crop in excess, and this combined with ammonia, gives an acreage produce even rather less than was obtained in the previous year without the minerals, and the *proportion of increase* over the unmanured plot is very little greater. In the sixth season we have, with a larger supply of nitrogen than usual, namely, with 200 lbs. of sulphate and 200 lbs. of muriate of ammonia per acre, an increase of 13½ bushels, or more than two-thirds over the unmanured plot. And in the seventh and last completed experimental season, this very heavy dressing of nitrogen is succeeded by a very liberal supply of minerals, which minerals however raise the produce only two bushels above the yield of the unmanured plot. Nothing can be more striking and conclusive than the evidence afforded by the fluctuations in the produce of this Plot 10*b*, as showing that it would be much nearer the truth to say that the crop has risen and fallen in proportion to the diminution or increase of the *ammonia* supplied to it in manure, than of the mineral substances, as would be

assumed according to the theory of Professor Liebig. It is seen, too, that it is only in the later seasons that the available minerals have appeared to be in defect, in relation to the nitrogenous supply.

That the mineral constituents are indeed becoming deficient in several of the plots of our experimental fields, we have in our collective results, as well on turnips and beans as on wheat, abundant evidence; and as the circumstances under which this point has actually been arrived at, are well understood, we are the better able to speak with confidence as to the non-exhaustion of them in other cases. Of this we shall on some future occasion speak much more in detail, when we are able to bring forward more of the experimental facts relating to it than we can do in a mere outline of this kind. But the plots to which we shall now refer will afford some illustration of it.

We have seen, then, that on Plot 10*a* there has been in every year since the first experimental one a large amount of ammoniacal salts, but without mineral supply; and that by this means we have in every year obtained a considerable amount of produce beyond that without manure. In Plots 18*a*, 18*b*, and 17*b*, on the other hand, we have *in every year mineral supply;* and in 1846, and ever since, this has been the same for these three plots, and always very liberal in nearly all the constituents required by the crop,—and in addition to this very liberal mineral provision, we have in each year, on one or more of these plots, exactly the same ammoniacal supply as in Plot 10 *a*, which had no mineral manure, so that we are thus enabled to show at what point the mineral supplies of the native soil were, in 10 *a*, deficient, in relation to the quantity of ammonia artificially applied to it. For the particulars of the manures of Plots 18*a*, 18*b*, and 17*b*, we must refer the reader to Tables 7, 8, 9, respectively, but the comparisons of produce to which we wish now to call attention will be better seen in the summary table, No. 11.

Thus, taking the cases of exactly similar ammoniacal supply, but in Plot 10*a* *without* mineral, and in the plot compared with it, *with* minerals, we have in 1845,—

On Plot 10*a*, 31¾ bushels of dressed corn and 4266 lbs. of straw, by 168 lbs. each, of sulphate and muriate of ammonia.

On Plot 18, 33 bushels of dressed corn and 3819 lbs. of straw, with only 112 lbs. each, of the ammoniacal salts, but *with* mineral manure.

In 1846, with equal ammoniacal supply in the two cases, we have,—

On Plot 10*a*, 27⅓ bushels of dressed corn and 2244 lbs. of straw, *without* minerals.

On Plot 17*b*, 30½ bushels of dressed corn and 2784 lbs. of straw, *with* minerals.

In 1847, with ammoniacal supply only, we have,—

On Plot 10*a*, 25¾ bushels of dressed corn and 2891 lbs. of straw.
On Plot 18*a*, 32¼ bushels of dressed corn and 3852 lbs. of straw, *with* minerals added.

In 1848, we have,—

On Plot 10*a*,* 19¼ bushels of dressed corn and 2367 lbs. of straw.
On Plot 18*a*, 26¾ do. do. and 2935 lbs. do.

In 1849, we have,—

On Plot 10*a*, 32½ bushels of dressed corn and 2854 lbs. of straw.
On Plot 18*a*, 32⅓ do. do. and 3592 lbs. do.
On Plot 17*b*, 33⅓ do. do. and 3858 lbs. do.
with minerals added to the two latter plots.

In 1850, again with ammoniacal salts only, we have,—

On Plot 10*a*, 27 bushels of dressed corn and 3089 lbs. of straw.

And the minerals and ammonia give—

On Plot 18*a*, 29¾ bushels of dressed corn and 3927 lbs. of straw.
On Plot 17*b*, 29½ do. do. and 4034 lbs. do.

Thus it appears, then, that although Plot 10*a*, with ammoniacal salts only, has given every year a considerable increase beyond that of the unmanured plot, yet the ammoniacal salts thus supplied were evidently much in excess over the minerals available within the soil; for in every case when minerals have been *also* liberally supplied, we have in corn, straw, or both, a considerably larger increase still. In 1849, indeed, the excessively mineral-exhausted plot (10*a*) gives about the same quantity of corn as those which had always a liberal provision of mineral constituents. The straw, however, is deficient.

The effect of mineral manures for the growth of wheat is then, in these cases, clearly shown:—but what are the circumstances under which this result is obtained? It is only when, after taking from the land the whole produce of a rotation without return, we provide *ammoniacal salts alone*, in such quantity as to yield crops year after year larger than the average obtained in the county under the ordinary course of rotation and home manuring; and the produce thus obtained by ammoniacal salts only, was very nearly equal to that resulting from an annual supply of 14 tons of farm-yard manure. We by no means suppose, however, that if some cheap source of ammonia were discovered, we might with

* The produce of this plot being so small, we had been disposed to suspect that some mistake had arisen either during the harvest or at the time of threshing. It was however observed that the crop in this season was particularly irregular and sickly where there was a deficiency of minerals; but as the produce of this plot (10*a*) was at the following harvest (1849) considerably more than we should have anticipated, we are disposed to believe that the result as stated for 1848 is probably correct, and that the high rate of increase by ammoniacal salts alone, in 1849, was partly due to the *non*-exhaustion by the previous crop.

impunity continuously exhaust our soils in the growth of corn by its means; but, on the contrary, fully admit that under such a course our mineral supply would soon become deficient. This is not the condition of British agriculture, and it is not for *such* circumstances, therefore, that we have at present to provide.

But to recur to the summary table. We see that notwithstanding in the two cases there was an equal and very liberal supply of minerals in 18*a* and 18*b*, we have with the cessation of ammoniacal supply in the latter, in 1846, a produce 10 bushels less than in the former, where the ammoniacal salts were continued. The produce of 18*b*, indeed, with the minerals only, is 3¼ bushels of corn and about 380 lbs. of straw more in 1846 than on the unmanured plot; but this exhaustion, by means of a liberal provision of minerals, seems to have been not without its effect upon the succeeding crop; for although, in 1847, Plots 18*a* and 18*b* are equal, both in mineral and ammoniacal manure, we have in the latter—which we have just seen gave 3 bushels increase under mineral only, in 1846—3 bushels *less* in 1847 than 18*a*. The straw, however, of 18*b* is about 300 lbs. heavier than that of 18*a*.

We may here observe that the production of straw, as well as that of grain, would seem to be intimately connected with the expenditure of nitrogen derived through the roots of the plant, and had we time to consider the question more fully on this occasion, we should not have dwelt so exclusively on the production of corn alone as we have done. We may, however, remark, that the production of a heavy crop of straw in a wet season is probably, from the cause alluded to, a very dearly purchased produce.

We have already said that, excepting in the first two seasons, the mineral manures of 17*b* were exactly the same as those of 18*a* and 18*b*, and although we have seen that the minerals of these plots have rendered the ammoniacal supply more effective than it was on 10*a* without the minerals, yet we observe that when, in 1847 and 1848, we give to 17*b* an *additional* quantity of ammoniacal salt, the produce is increased beyond that of 18*a* and 18*b*. Thus we have in 1847, with an increased amount of ammoniacal salt on 17*b*, 3¼ bushels more dressed corn and about 400 lbs. more straw than on 18*a* with its equal supply of minerals: and again, we have in 1848, on 17*b*, two bushels more dressed corn and 400 lbs. more straw than on 18*a*. It is clear then that the minerals supplied, which have been throughout much more than equivalent to those taken off in the increased produce, were only available so long as there was a liberal provision of nitrogen *in the soil;* and that when this artificially supplied nitrogen was exhausted, the minerals remained inactive and useless. We have, then, in the very cases where minerals gave an increased produce,

in the well-defined limit to their action which is indicated, further proof of the necessity of an artificial supply of nitrogen *in the soil* for the increased production of corn, and the incapability of mineral supply to yield any increase, excepting when nitrogen is thus provided.

Turning now to Table X., we find that the 98 tons of farm-yard manure which have been supplied during the last seven years have only given an increase of 73 bushels of dressed corn and 3 tons 15 cwts. of straw over the unmanured plot. This is equivalent to only $\frac{3}{4}$ of a bushel of corn and $\frac{3}{4}$ of a cwt. of straw for every ton of farm-yard manure supplied! Farm-yard manure is, however, a very variable compound; its composition being dependent upon the amount and quality of the food consumed by the animals which have produced it. According to the mean of several direct experiments upon very rich box-manure, a ton of it, in round numbers, is composed of $14\frac{1}{2}$ cwts. of water, and $5\frac{1}{2}$ cwts. of dry substance, the latter of which contains a large quantity of mineral matter and nitrogen equal to about 20 lbs. of ammonia; on the other hand, a ton of manure composed merely of straw wetted to the same degree, with of course the same amount of dry substance, only gives nitrogen equal to about 5 lbs. of ammonia, and probably much less than half of the more important minerals of the rich box-manure. The farm-yard manure carried out of our yards, as to nitrogen, will generally have a composition intermediate between these two extremes; and we may at any rate assume that that which we employed would contain about 5 cwts. of dry substance, of which the dry organic matter, rich in carbon, would be three or four times as great as, and the minerals also much in excess of, that required by the increase of corn and straw which we have seen to be obtained by their use. It is evident therefore that there must have been a great expenditure of non-nitrogenous organic substance, and of mineral matter, without effect; and we conceive that the increase obtained was much more intimately connected with the amount of nitrogen contained in the manure supplied. This view, indeed, would appear to be beyond doubt when we consider that the application of ammoniacal salts alone, during the last six years, as in plot 10*a*, has given an average increase within one bushel of that which has been obtained by the use of farm-yard manure.

Neither *mineral manures* nor *carbon* then, are indicated by our experiments as the special or direct manures for the growth of wheat. Not so, however, with the turnip, for the successful cultivation of which a liberal supply within the soil of carbonaceous substance and phosphates is found to be important. We have here then a remarkable contrast—for if in practice the Wheat plant be supplied with a sufficient amount of nitrogen,

lusive, at

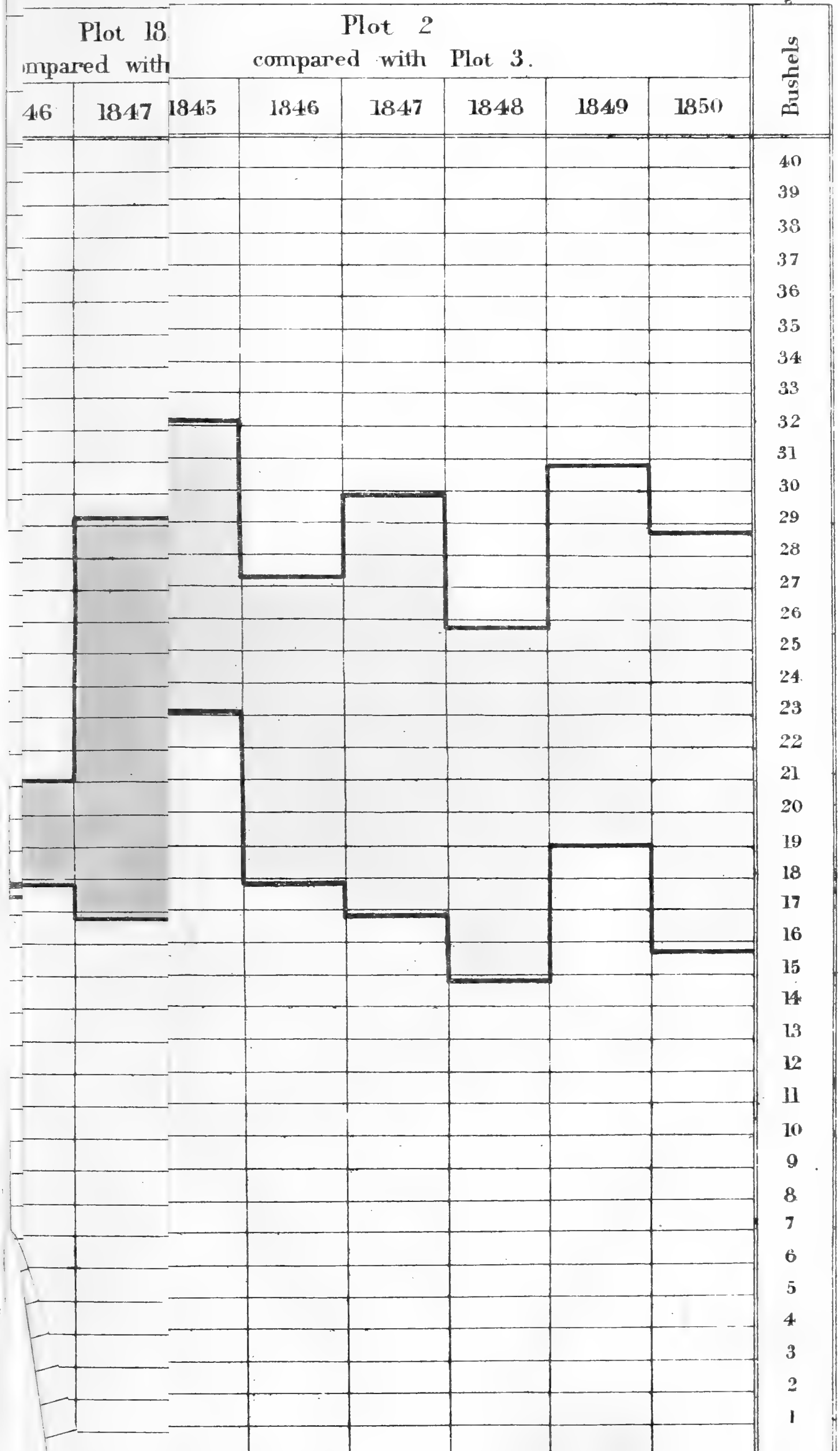


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DIAGRAM II. Showing the results, as to Dressed Corn, given in Tables 5 to 10 inclusive, at pages 16 to 21 respectively.

Explanation of Diagram II.

The general plan of this Diagram is much the same as that of the preceding one

But here each Section refers throughout to the produce of one & the same plot but traced through the successive seasons since the commencement of the experiments. And in each case compared with that of the continuously unmanured plot in the same season.

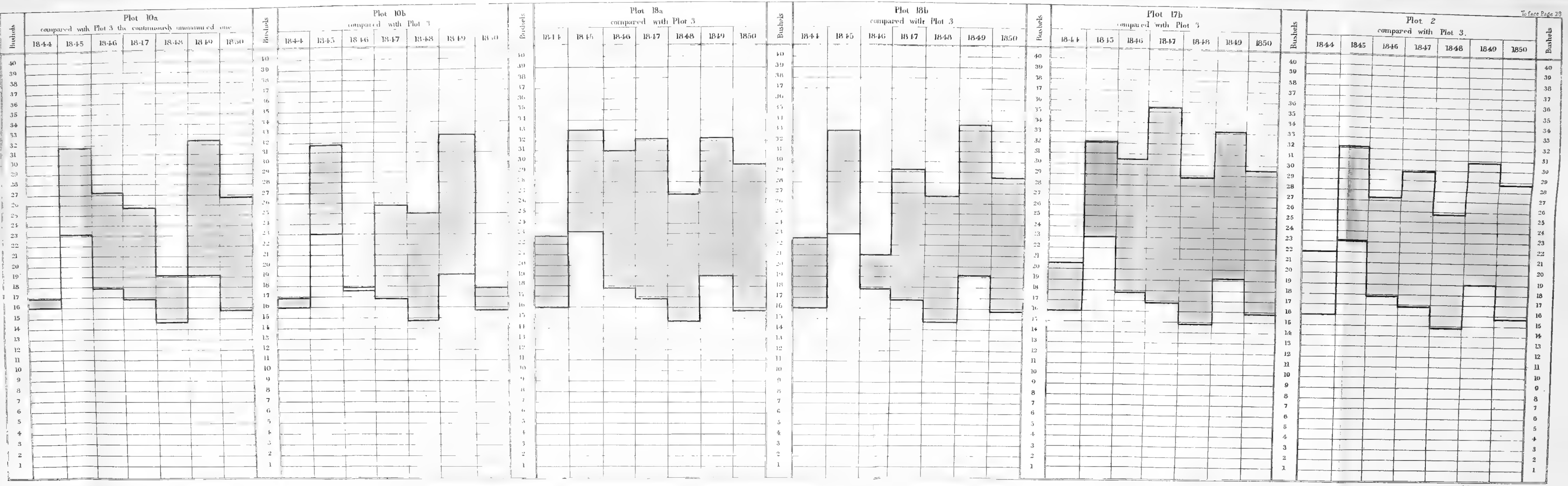
The results here given are the same as those numerically arranged in Tables 5 to 10 inclusive.

As before the lower uncoloured portion of the columns represents the produce on the continuously unmanured plot and the fluctuations according to season are here clearly brought to view.

The coloured portions again represent the increase of produce by manure beyond that obtained on the unmanured plot.

The particular kind of manure indicated by each color is here repeated.

Blank	*Unmanured*
Grey	*Farm Yard Manure*
Blue	*Mineral Manure only*
Red	*Ammoniacal Salt only*
Yellow	*Minerals & Ammoniacal Salt*
Brown	*Minerals Rape Cake and Ammoniacal Salt*



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it is not likely to be deficient in carbon or in mineral matter; while the Turnip, on the other hand, will not be provided with the due quantity of carbon independently of a coincident and frequently sufficient supply of nitrogen. And it is in this conversion into useful food for stock by the Root crop of the carbonaceous matter of our straw, which, after it has served as litter, would, beyond this, be a comparatively useless refuse of our grain crops, that phosphoric acid is found to be a very active agent; whilst of the nitrogen stored up in the growth of the root crop, a much larger proportion than of the carbon remains in the excrements of the animals, and serves in its turn for the growth of the succeeding cereal grain: and hence is seen a mutual reliance between these two important crops of rotation. But to the influence of phosphoric acid upon the turnip crop we shall recur again presently.

But there is another point in connexion with the great demand made by the wheat plant upon nitrogen supplied to the soil, to which we wish to draw particular attention.

Thus, among from two to three hundred experiments with ammoniacal manures, we have in no single instance recovered in the increase the amount of nitrogen provided in the manure; and this fact is perfectly consistent with the amounts of produce found, in the experience of the farmer, to be obtained by the use of Peruvian guano and other nitrogenous manures. Part of this result is doubtless due to the limited range of the roots of the plant in relation to the distribution of the manure in the soil; but much of it is materially dependent on a definite expenditure, so to speak, of nitrogen, which is taken up by the roots of the plant and given off by its leaves to the atmosphere in the exercise of the functional actions of its growth.

De Saussure, Daubeny, and Draper have found that nitrogen was really thus given off during the growth of certain plants; but in a practical point of view the question still arises whether this is uniform with all the different plants which enter into a rotation.

In relation to this subject we have ourselves, during the last two years, undertaken a series of experiments, in the hope of sooner or later elucidating this truly interesting and important subject. We cannot here enter into a consideration of the results which have been thus obtained, but we may briefly indicate a probable conclusion to which the experiments would seem to lead, the results of a preliminary series of which have already been published in the Journal of the Horticultural Society, for January 1850. Thus we have found, that whilst for a given quantity of water passed through the plant during its growth the amount of *non*-nitrogenous substances fixed in it is, within somewhat narrow

limits, identical; that of the *nitrogenous* proximates fixed is, on the other hand, about *twice* as great in the Leguminosæ as in the Graminaceæ. This fact, too, perfectly coincides with the results of our experiments in the field, with wheat and beans respectively, which show that under the same circumstances of growth, as to manure, &c., and in the same season, the *acreage* yield of nitrogen is twice or thrice as great in beans as in wheat. It cannot be supposed, however, that with the larger amount of nitrogen harvested in the leguminous crop the soil would be proportionally exhausted of it, for common practice teaches that, other things being equal, wheat, which is especially dependent on the supply of nitrogen in the soil, would give a larger produce after a bean than after a wheat crop.

Here then it would appear that there is evidence of a superior power in the leguminous, as compared with the graminaceous plants, of obtaining their nitrogen from the atmosphere rather than from the soil; or it may be supposed that the expenditure of it during the growth of the plant is greater in the one case than in the other.

In support of the view that leguminous plants do possess a superior power of reliance upon the atmosphere for their nitrogen, and, indeed, that it is to this property that they materially owe their efficacy in rotation with grain, we may refer to the admirable investigations into the Chemistry of Agriculture of M. Boussingault. His experiments, however, have not received the attention which they merit from the agriculturists of this country; probably on account of the small amounts of produce which he obtained. But it must be remembered that his investigation had for its object to explain the practices of agriculture as he found them in his own locality, before attempting to deviate from its established rules. M. Boussingault states the rotation usually adopted at Bechelbronn, and throughout the greater part of Alsace, to be as follows:—

"Potatoes or beet-root,"
"Wheat,"
"Clover,"
"Wheat;"

and that the average of wheat so obtained is, after potatoes 19½ bushels, after beet-root 17 bushels, and after clover 24 bushels. Now we find by reference to his table that the first crop of wheat, grain, and straw removed 17 lbs. of phosphoric acid and 24 lbs. of potash and soda; the following clover crop, 18 lbs. of phosphoric acid and 77 lbs. of potash and soda; and after this removal of alkalies and phosphates by the clover, a *larger* crop of wheat is obtained. Surely it would seem impossible to reconcile

this result with a theory which supposes the produce of wheat to rise and fall with the quantity of minerals available within the soil. If, however, we admit that the first crop of wheat could not take up the mineral matters existing in the soil for want of nitrogenous supply, and that the clover crop, not being so dependent upon *supplied* nitrogen, was able to take up the minerals required for its growth, and that it moreover left in the soil, sufficient ammonia, or its equivalent of nitrogen in some form, to give the *increased* crop of wheat, we have a much more consistent and probable solution of the results. There is little doubt that M. Boussingault could have increased his produce of wheat by means of ammoniacal salts: whether he could have done so economically is another question, depending of course upon the relative prices of grain and ammonia.

In our paper upon the growth of wheat, published in the Journal of the Royal Agricultural Society in 1847, we have attempted an estimate of the probable amount of nitrogen required to obtain a given amount of it in the increased produce. We there provisionally assumed that 5 lbs. of ammonia were required to produce an increase of one bushel of corn and its equivalent of straw. We do not intend to enter fully into the question of the accuracy of this estimate on the present occasion, but we may observe in passing, that among the plots the history of which we have given in the foregoing pages down to the last harvest, there is not one, even under the best conditions as to artificial mineral supply, where the ammonia, on the average of seasons, has given an increase equal to that supposed in our estimate. And even supposing that the farm-yard manure employed in our experiments contained no more nitrogen than we have stated would have been provided in merely wetted straw, we have not obtained by its means as much as a bushel of corn and its equivalent of straw for each 5 lbs. of ammonia thus supplied in the manure. It may be said, perhaps, that the circumstances of experiments wherein wheat has been grown for several years successively on the same land, are very artificial; but such is the result which they have yielded, and it is at any rate worthy of the serious attention of the reader. In some cases of our experiments, however, which are in no degree less artificial, a slightly better result has been obtained. But to this point we shall recur on some future occasion.

Without further inquiring then, into the correctness of our estimate, it would seem that a loss of this kind during the growth of the plant is a fact which is sufficiently substantiated, at once by the practical experience of the farmer, and by experiments of an independent kind relating to it. And, let it once be recognised, in agricultural science, that there is a definite expenditure or

consumption of the nitrogenous bodies derived through the roots, connected with the fixation and elaboration of certain constituents of plants, and that this is greater or less according to the sources or the exact composition or state of elaboration of the products, and an important step will be gained towards a clearer conception of the principles involved in the alternation in a course of cropping, of plants of varying products and habits of growth. The fallacy, too, of the theory which would supply to plants a manure, founded on a knowledge of the percentage composition alone, whether of their ashes or of their organic substance, will at once be obvious. Nay, the converse of the axiom herein implied is more nearly true, at least in some important cases; for, as we have elsewhere asserted, with regard to the Wheat and Bean plants for example, the former, that is the Wheat, as compared with the latter, is characterized by a low percentage of nitrogen and a relatively high percentage of carbon; but all experience and the tendency of all our results is to show, that the low nitrogenized Wheat crop requires for its luxuriant growth an abundant supply of *nitrogen* by *manure*, and that with this it is *practically* independent of *supplied* carbon; whilst the highly nitrogenous Leguminous plant is, other things being equal, by no means strikingly and characteristically benefited by nitrogenous manures. Were it otherwise, where would be the subserviency of the leguminous plants grown in rotation with grain? We had, indeed, at one time supposed that *clover* was greatly dependent on an artificial provision of nitrogen, but this view is not favoured by further investigation; whilst with it, as well as with those leguminous plants valued in agriculture for their seeds, which are known practically to occupy a peculiar sphere when grown in alternation with the cereal grains, a *mineral*, and especially an *alkaline* manure, seems to be more prominently indicated. Indeed, it is to the *fallow crops* generally, or those which are grown in alternation with grain, that direct mineral manures are of essential service in enabling them to accumulate stores from the atmosphere; and in *this sense* indeed special mineral manures may be said to be subservient to the increased growth of grain. And, the effect of alkalies upon leguminous plants, perhaps approaches more nearly to consistency with the theory of Baron Liebig than any other fact which has come under our observation, for the alkalies, which we have found to have a very marked effect upon their increased growth, predominate largely in their ashes.

A beautiful illustration of the dependence for luxuriant growth of one plant upon another of different habits, such as we have shown above, may be found in the case of the "fairy rings," where the fungus, by virtue of its extraordinary power of rapidly

accumulating nitrogen from the atmosphere during its growth, taking up the minerals which the grasses, from their more limited power in this respect, could not appropriate, an abundance of provision of the nitrogenous manure so effective in the growth of the grasses, which are observed to spring up with great luxuriance wherever the fungus has grown or fallen.

But again, judging from the composition of the ash of the turnip, which shows, both in the leaf and in the bulb, a proportion of alkalies to phosphoric acid of from four or five to one, we might be led to decide that the former, rather than the latter, were usually and specially the more appropriate manures for the turnip. Common practice has, however, definitely determined in favour of phosphoric acid rather than of the alkalies, as the special manure to be provided for the turnip, from sources external to the farm itself.

The striking effect of phosphoric acid upon the growth of the turnip, indeed, is a fact so well known to every intelligent agriculturist in Great Britain, that it would seem quite superfluous to attempt to illustrate it by any direct experiments of our own. However, as Professor Liebig has again, in the recent edition of his 'Letters,' expressed an opinion entirely inconsistent with such a result, we will refer to one or two of the results obtained in our experimental turnip-field, which bear upon the opinion he has reiterated as follows:—thus, speaking of the exhaustion of phosphate of lime and alkaline phosphates by the sale of flour, cattle, &c., he says:—"It is certain that this incessant removal of the phosphates must tend to exhaust the land and diminish its capability of producing grain. The fields of Great Britain are in a state of progressive exhaustion from this cause, as is proved by the rapid extension of the cultivation of turnips and mangold-wurzel, plants which contain the least amount of the phosphates, AND THEREFORE REQUIRE THE SMALLEST QUANTITY FOR THEIR DEVELOPMENT!"* Now we do not hesitate to say that, however small the quantity of phosphates contained in the turnip, the successful cultivation of it is more dependent upon a large supply of phosphoric acid in the manure than that of any other crop.

In the following table, then, is given the amounts of bulb† since 1843, of—

First, the continuously unmanured plot;
Secondly, that with a large amount of superphosphate of lime alone each year; and

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* See the third edition of the 'Letters on Chemistry,' page 522.
† Norfolk Whites in 1843-4-5-6-7-8, and Swedes in 1849 and 1850.

Thirdly, that with a very liberal supply of potash with some soda and magnesia also, in addition to superphosphate of lime.

Years.	Plot continuously Un-manured.				Plot with Superphosphate of Lime alone every Year.				Plot with Superphosphate of Lime and mixed Alkalies.			
	Tons.	cwts.	qrs.	lbs.	Tons.	cwts.	qrs.	lbs.	Tons.	cwts.	qrs.	lbs.
1843	4	3	3	2	12	3	2	8	11	17	2	0
1844	2	4	1	0	7	14	3	0	5	13	2	0
1845	..	13	2	24	12	13	3	12	12	12	2	8
1846	..	..	..	..	1	18	0	0	3	10	1	20
1847	..	..	..	..	5	11	0	1	5	16	0	0
1848	..	..	..	..	10	11	0	8	9	14	2	0
1849	..	..	..	..	3	15	0	0	3	13	2	8
1850	..	..	..	..	11	9	0	0	9	7	1	12
Totals.	..	..	..	..	65	16	1	1	62	5	1	20
Means.	..	..	..	..	8	4	2	4	7	15	2	20

It is seen then, that in the third season, viz. 1845, the produce of the unmanured plot is reduced to a few hundredweights, and since that period the size of the bulbs has been such that they have not been considered worth weighing. On the other hand, on the plot with *superphosphate of lime alone* for eight successive years, we have an average produce of about $8\frac{1}{4}$ tons of bulb! varying, however, exceedingly, year by year, according to the season. We see, too, that by the addition to superphosphate of lime of a large quantity of the alkalies, much greater than could be taken off in the crop, the average produce is not so great by nearly half a ton as by the superphosphate of lime alone. It must be admitted that this extraordinary effect of superphosphate of lime cannot be accounted for by the idea of merely supplying in it the actual constituents of the crop, but that it is due to some special agency in developing the assimilative processes of the plant. This opinion is favoured by the fact that in the case where the superphosphate of lime is at once neutralized by alkalies artificially supplied, the efficacy of the manure would seem to be thereby reduced. And from this again, we would gather that the effect of the phosphoric acid as such, cannot be due merely to the liberation within the soil of its alkalies, or we should suppose that the artificial supply of these would at least have been attended with some increase of produce. But this is not the case, notwithstanding that by means of superphosphate of lime alone there has been taken from the land more of the alkalies in which the ash of the turnip so peculiarly abounds, than would have been lost from it in a century under the ordinary course

of rotation and home manuring! Collateral experiments also clearly prove the importance of a liberal supply of organic substance rich in *carbon*—which always contains a considerable quantity of nitrogen also—if we would in practical agriculture increase the yield much beyond the amount which can be obtained by mineral manures alone; and these conditions being fulfilled, the direct supply of nitrogen, on the other hand, is by no means so generally essential. And it is where we have provided a liberal supply of constituents for organic formations, in addition to the mineral manures, that we have found the use of alkalies not to be without effect.

But it is at any rate certain that phosphoric acid, though it forms so small a proportion of the ash of the turnip, has a very striking effect on its growth when applied as manure; and it is equally certain that the extended cultivation of root crops in Great Britain cannot be due to the deficiency of this substance for the growth of corn, and to the less dependence upon it of the root crops, as supposed by Baron Liebig.

These curious and interesting facts in relation to the growth of turnips, as well as those which have been given in reference to wheat and to the leguminous crops, are sufficient to prove how impossible it is to form correct opinions on agricultural chemistry without the guidance of direct experiment in the field. And we are convinced that if Baron Liebig had watched the experiments which we have had in progress during the last eight years, he would long ago have arrived at conclusions in the main agreeing with those to which we have been irresistibly led: and we are disposed to believe that had he even seen the more detailed accounts of our results given in our own papers in this Journal, instead of the mere reference to them made by Mr. Pusey, he would rather have accepted them, as a step in an inquiry to which his own researches and writings had given such an impetus, than have designated them, as he has done, as entirely without value.

So much, then, for the results of experiments in the field, and for the considerations in relation to the functional actions of plants, as bearing upon the character of the manure required for their growth in a course of practical agriculture. Let us now consider for a few moments what really are the main and characteristic features of practical agriculture, as most generally followed in this country.

Let us suppose that the rotation adopted is that of Turnips, Barley, Clover, Wheat; that the turnips and clover are consumed upon the farm by stock, and that the meat thus produced, 40 bushels of barley and 30 bushels of wheat, are all the exports from the farm, the manure from the consumed turnips and clover,

and the straw, both of barley and of wheat, being retained upon the farm. We have in this case, by the sale of grain, a loss of minerals to each acre of the farm of only 20 to 24 pounds of potass and soda, and 26 to 30 pounds of phosphoric acid, in the course of the rotation, or an average of 5 to 6 lbs. of potass and soda, and $6\frac{1}{2}$ to $7\frac{1}{2}$ lbs. of phosphoric acid per acre per annum. In the sale of the animals there would of course be an additional loss of phosphoric acid, though, especially if no breeding-stock were kept, this would be even much less considerable than in that of the grain; and the amount of the alkalies thus sent off the farm would, according to direct experiments of our own upon Calves, Bullocks, Lambs, Sheep, and Pigs, probably be only about one-fourth that of the phosphoric acid. It has, however, long been decided in practical agriculture that phosphoric acid may be advantageously provided in the purchase of bones or other phosphatic manures, though in practice these are not found applicable as a direct manure for the wheat crop; and as we have already said, even when employed for the turnip, its efficacy is not to be accounted for merely as supplying a sufficiency of that substance to be stored up in the crop.

Of the minerals then, to be supplied by external sources yet to be discovered or developed, the question lies with the alkalies; and of these there will in the sales of corn supposed above, be, under any circumstances, only 5 to 6 lbs. per acre per annum required to be provided from the stores of the native soil by annual decomposition, in order that the immediately available supply of them, which has thereby been drawn upon, should be undiminished.

But we believe that few will maintain that the amounts of produce above supposed are, in practice, exported, unless under a system of purchased food for stock, or of such substances as rape-cake as manure for turnips; and by neither of these means could the produce thus be raised, without bringing upon the farm more of the alkalies than could possibly be exported, in the increased produce of corn and meat arising from their use. Under such a course, then, and this is what happens wherever land is well cultivated, the demand upon the native soil for alkalies, by the sale of corn, will probably be less than has been assumed; and it is even possible that in actual practice the available alkalies of the soil will, from the two causes of import and disintegration, accumulate rather than diminish.

In justification of the supposition that cattle-food must be imported, if the sales of corn and consequent export of alkalies are to be thus kept up, it must be remembered that the relative price of meat and corn, and that of manures to both, as fixed by the laws of supply and demand, would at present, at least, preclude

the idea of the produce of the latter, that is corn, being maintained irrespectively of that of the former—that is to say, by imported manures alone, and to the exclusion of the consumption of food upon the farm by stock. And here we might suggest as a consideration well worth the attention of practical men, as a test of the "Mineral Theory," how it would be possible that the increased growth of wheat should be so limited and that its cost should be so great as in experience it is found to be, if the only manure required were the mineral constituents found in its ashes? And further, we would ask how, on the idea, on the other hand, that the nitrogen supplied in our manures determines the produce of wheat, they could account for the relative prices of wheat and ammonia, unless on the supposition that the expenditure and loss of the latter during the growth of the plant, is a fact which fundamentally affects the production and cost of grain in practical agriculture?*

But to return to our illustration. The animals kept upon the farm for *labour* too, must either consume part of the produce of the farm itself, in which case the sales of corn must be reduced, and consequently the exhaustion of the alkalies also, or they must be provided for by purchased food; in which case, while most or all of the minerals of such food will be retained upon the farm, much of its *Nitrogen,* and more still of its *Carbon,* will be lost by the vital processes.

It will be understood that the precise circumstances assumed in the illustration which we have given, will only be met with in certain cases, but whatever deviation from it may be found in ordinary practice in Great Britain, we believe that the line of argument here adopted is very generally applicable, and that it will also generally lead to a similar result.

It is true that owing to proximity to large towns, or other local circumstances, in many cases hay and straw, and even root-crops, may be sent off the farm; but in such cases local circumstances are generally found fully to compensate for this otherwise exhausting process, by the return of stable manure, night-soil, and other natural town manures. Indeed, that the alkalies are not relatively to nitrogen exhausted by the sale of straw in the neighbourhood of London, for example, is evident from the extensive use and marked effects even of soot and other non-mineral manures on the land from which this straw is taken. But if it were not so, such instances need not come into our calculations when speaking of agriculture generally.

But further, Baron Liebig has said that a knowledge of our

* One hundredweight of Peruvian guano will supply as much *phosphoric acid* as would be contained in about 18 bushels of wheat and its equivalent of straw—say 1800 lbs.! And of *nitrogen* this quantity of guano will contain about as much as 11 bushels of wheat and 1100 lbs. of straw!

experience of fallow is sufficient to show the fallacy of our opinions; but in this very process, and that even of liming also, when rightly considered, we believe we see that which should give confidence in the views we have maintained. It cannot be doubted that by the processes of fallowing and liming, the disintegration of the minerals of the soil, and the increase of the available supply therefore of their several constituents, must thereby be enhanced. But notwithstanding we have in the direct experiments of Wiegmann and Polstorff, of Rogers, and others, sufficient evidence of such disintegration under the action of air and water; yet there is, in our opinion, equal reason for believing that the processes of fallowing and liming owe their efficacy, as much or more to the changes which take place within the soil in regard to the available supply of the nitrogen which plants require, as of their purely mineral constituents. Thus Professor Mulder has concluded that the organic acids of the soil which he has investigated, have the power of accumulating ammonia from the atmosphere. Now these compounds will only be *retained* within the soil where organic matter is subject to a very slow process of decomposition, and it is precisely in the *heavier soils,* where the processes of fallowing and liming are found to be most beneficial, that organic matter will be shut up and subject to a very slow decomposing action, which these processes will materially assist. But more important still;—the experiments of Mr. Way on the absorptive properties of soils have directly proved, what was before indeed supposed, that it is the heavier soils, those again therefore that are most influenced by fallowing and liming, that possess in the highest degree the power of absorption and retention of ammonia and other substances, to the action of which they may be exposed. We do not, indeed, mean to say that the processes in question owe their value entirely to the influence of the actions to which we have alluded; but we think it may reasonably be suggested that there is, at least, as much evidence in favour of this view of the efficacy of fallowing more especially, as in the mineral theory of it; and the more so when we remember that it is the wheat crop, for which nitrogen *in the soil* is found to be so important, that almost invariably succeeds the fallow. And the fact that mineral substances do at the same time accumulate, should itself give confidence in views which, on independent grounds, suppose that they are not so easily liable to be found in defect in relation to other necessary supplies.

Reviewing, then, the actual facts of practical agriculture, as generally followed in Great Britian, we have seen how small is the utmost annual loss of alkalies under the export of corn and meat alone, and that the demand thus made upon the stores of the native soil will generally be truly insignificant. Phosphoric

acid, on the other hand, is sent off the farm in much larger quantities than the alkalies; but under good cultivation it is already in actual practice frequently more than restored by the import of cattle food, or direct manures, such as bones, guano, &c. Baron Liebig, indeed, himself asserts that farm-yard manure is the universal food of plants; and we should never lose sight of the fact, that the very practice of agriculture in this country necessitates the production of this manure, by means of which it is that so large a proportion of the mineral elements of the crops raised upon the land are in due time restored to it; all our calculations, therefore, should be made on a full consideration of what is involved in its use. This is, however, not generally sufficiently borne in mind by chemists unconnected with practical agriculture; and to this cause may, in great part, be attributed the reiterated recommendations to imitate in artificial manures the composition of the ashes of the plants to be grown.

But further than this, taking into careful consideration the tendency of all experience in practical agriculture, as well as the collective results of a most laborious experimental investigation of the subject, both in the field and in the laboratory, it is our deliberate opinion that the analysis of that portion of a crop which is sent off the farm, whether of its organic substance or of its ashes, is no DIRECT guide whatever as to the nature of the manure required to be provided for its increased growth in the ordinary course of agriculture, from sources *extraneous to the home manures of the farm;* that is to say, by artificial means.

In conclusion, then: if the theory of Baron Liebig simply implies that the growing plant must have within its reach a sufficiency of the mineral constituents of which it is to be built up, we fully and entirely assent to so evident a truism; but if, on the other hand, he would have it understood that it is of the mineral constituents, as would be *collectively* found in the ashes of the exported produce, that our soils are deficient relatively to other constituents, and that, in the present condition of agriculture in Great Britain, "we cannot increase the fertility of our fields by a supply of nitrogenized products, or by salts of ammonia alone, but rather that their produce increases or diminishes, in a direct ratio, with the supply of mineral elements capable of assimilation," we do not hesitate to say that every fact with which we are acquainted, in relation to this point, is unfavourable to such a view. We have before stated, however, that if a *cheap* source of ammonia were at command, the available mineral constituents might in their turn become exhausted by its excessive use.

But it is at any rate certain that for *wheat*, of all our crops, no supply of minerals, phosphates, &c., to the fields of Great Britain generally, will enable it to "obtain a sufficient supply of ammonia

from the atmosphere;" and, indeed, that any increased produce of it, such as British agriculture (itself so artificial) demands, cannot be obtained independently of an artificial accumulation of nitrogen *within the soil.*

Of those crops of rotation, on the other hand, where the effect of mineral manures is characteristically to increase the assimilation of nitrogen from atmospheric sources, and by virtue of which property they indeed become subservient to the increased growth of grain, the apparent demand for these substances is not only generally not such *in kind* as would be indicated by an analysis of their ashes, but is frequently much greater *as to quantity* than can be accounted for by any idea of merely supplying what is to become an actual constituent of the crop. If, then, we would attain by the aid of science a rational system of agriculture, the actual facts of the art itself, as well as the indications of direct experiments in the field, and a study of the functional actions of plants and animals, must receive a due share of our attention. In fact, chemistry *alone* will do nothing for practical agriculture.

NOTE.—This important paper so completely establishes what I wrote in our last Number on the entire failure of the Mineral Theory as a guide to the use of manures in practical farming, that I need only express my regret for the annoyance which its author has publicly expressed, as I am told, at those remarks. In cautioning the English farmer against what seemed to me a dangerous error, I certainly endeavoured to do justice to the real discoveries of Baron Liebig. Since the experiments, however, of Mr. Lawes and Dr. Gilbert have, as I hear, been disputed, I am bound to say that my confidence in the scrupulous accuracy of those gentlemen has been only strengthened by a subsequent visit to Rothamstead, in company with that eminent philosopher Mons. Dumas. The extent of the experimental ground—the expenditure at which it has been kept up—the perseverance with which, year after year, it has been maintained, are such as might rather be expected from a public institution than a private landowner, and render Rothamstead, at present, the principal source of trustworthy scientific information on Agricultural Chemistry.

PH. PUSEY.

II.—*On Draining, under certain Conditions of Soil and Climate.* By Lord Wharncliffe.

To *Mr. Pusey.*

My dear Pusey,—If you can afford me a small space in the next Number of the Journal, I am tempted to ask it, in order to lay before its readers a brief explanation of certain conclusions and methods to which I have been led—or I may say driven—in the course of my experience of draining operations, now not inconsiderable in extent. Everything connected with the subject is of primary and vital interest to agriculture, as few will now be found to dispute; and I think it may be useful if I make this unpretending contribution to it, for discussion, at any rate, if not for adoption by others.

I have been executing such work here, since 1847, upon rather a large scale, by means of an advance from the first parliamentary grant, and have had, therefore, good cause to look carefully into the whole matter, that I might qualify myself for directing it, so as to satisfy Her Majesty's Commissioners as well as my own mind. I have lost no opportunity of studying the best authorities, or of inspecting the works of others whenever they came within my reach; and I offer these assurances as the credentials for my information and opinions.

All that I heard, read, or saw, worked in me the early but profound conviction, which has never since been shaken, that in the vast majority of cases mere shallow draining is but shallow trifling. The evil lies generally as deep as the vegetation, and if the limit of this is often beyond our reach, at any rate we should approach it as near as may be in our power. There are few instances in which I would now willingly stop short of a good four feet;—three feet I believe to be a *minimum* for the main framework of the system. I add to this that of all materials the best are good pipe tiles,* not too small in size; and that the dominant direction should in almost all cases be that of the slope to be drained. These appear to me to be almost the axioms of the science; and in whatever I may hereafter say as to certain specific variations or modifications, I beg to be understood as proceeding confidently upon this basis.

Still, experience, reflection, and observation, have convinced me that they are not, any more than other excellent canons, abso-

* I have seen and heard of so many cases where the pipes have become choked by various means, that I doubt if they are *universally* the best materials. I have also seen so many drains in excellent order, of considerable age, formed with materials suited to the locality where pipes tried in modern drains have already required to be taken up and cleansed, that I believe the question of "What are the best Materials?" is to be decided in each locality by local experience, and that no general rule is safe.—Portman.

lutely invariable, inflexible, or unexceptionable. It will be my business to show that, in the matter of depth at least, they are not to be taken as rules "*pures et simples;*" uniform under all varying circumstances, and always rigidly applicable under the same form. I hope to be able to convince my readers that there are conditions under which a certain amount of deviation, or rather perhaps of relaxation, may be admitted with advantage; and before I attempt this I may farther justify myself by stating that I have not presumed to enter upon it without having allowed a sufficient lapse of time to test my conclusions, however carefully considered; and to ratify them, to the best of my judgment and belief, by the only certain seal of practical success.

I have executed my work here at various depths and distances. In my first steps I was disposed to be cautious and empirical rather than theoretical and hasty. I was comparatively unacquainted with the peculiar elements of my case. I had, of course, many prejudices and misgivings to meet and to surmount; and I was solicitous that my commencement should not risk a failure of efficiency on the one hand, or on the other raise the cost too high. I began, therefore, with drains of 3 feet deep and 8 yards distance. These appeared to be safe dimensions; and I found that in most cases they produced not an unsatisfactory result. I have a good deal of ground apparently well dried upon this plan; still it did not always appear to answer quite equally well, even where the nature of the subsoil seemed to sanction it; and I was, moreover, not quite satisfied with the depth; which I had always considered rather as a *minimum* than as a standard measure. I therefore tried an extension of it to 3 ft. 6 in., also at 8 yards distance; but then the other end of the beam began to rise, and I found the *cost* augment, according to the accelerated ratio of a district of high wages, beyond the proper limit. I now therefore increased the *distance* to 10, and occasionally even to 12 yards, without perceiving much difference in the result; though on the whole, perhaps, it was less generally satisfactory than in the former case. Early in these operations I resolved to treat experimentally a field of about four acres in my own occupation, and to ascertain whether it would distinctly answer the plain but doubtful question which I wished to solve, if fairly put to it. I accordingly divided it into two halves, and drained one side at a depth of 3 feet, with intervals of 10 yards; the other to 4 feet deep, with 13 yards of distance; giving to each half a separate outlet. The field is one of a poor description originally, lying on a steep S.W. slope, which in this country implies across the edge of the geological beds; for the most part boasting but a limited amount of soil, covering a stiff yellow clay; but somewhat more generous at its upper edge, which was also its steepest part, and into which we thought it best to drive the drains still deeper

at their extremities,—to about five or six feet,—in order to reach well the outbreak of under-water which we believed it to contain. This field I watched with much interest. It was drained in the first month of 1848. It has had the advantage of being well broken up (especially the deeper half) for crops of roots; and yet I am obliged to confess that I never could satisfy myself as to any clear evidence of advantage on one side over the other; and at the present moment, near $3\frac{1}{2}$ years since the work was done, there are parts stretching over *both* the halves, of which the surface is undried, and that apparently with little reference to the vicinity of the drains; though the outlets have never failed to do their duty.

These last facts however, by no means unexampled in my experience here, and of which I have several other instances, seem to me to prove two things irresistibly; first, that to clear such ground of *bottom water* deep drains are indispensable, and, within rational limits, the deeper the better; and, secondly, that in soils so circumstanced the *surface* and the *bottom* drainage are two distinct things, with a real difference; of which, though the latter be complete and effective, the former may be at the same time a failure. Looking then, primarily, to the fundamental and permanent source of saturation in such land from beneath, my conviction has been only thereby strengthened, that it can be reached by deep drains alone; I accordingly adopted a depth of 4 feet in various localities. But then again, immediately sprung up the difficulty of the cost, depending inversely on the distances, which, when these were not proportionally expanded, became seriously heavy. To meet this I determined to try an interval between the 4-feet drains, in the first instance so much greater that it might be possible to interpolate others if a failure should require it. I placed them therefore at 16 or 18 yards apart, and I was the less doubtful of this course, because in some of these cases the subsoil seemed of a somewhat less tenacious character, owing to a certain silicious admixture in its substance. But I must avow that the experiment has not completely answered, and that still verdant rushes, with a spongy or pasty surface, proclaim that we have been partially baffled. It should be observed, however, in passing, that much of this land lies high and exposed, and where the temperature from various causes must needs be generally low.

These imperfect and unsatisfactory results seemed to tell me in clear language that the problem was still unsolved, and to bid me re-examine and carefully consider its elements before I could hope to meet its peculiar difficulties. The result to be, if possible, attained was, to devise a system which without, on the one hand, sacrificing what I believe to be the essential condition of *depth*, or, on the other, unduly exceeding that of *cost*, might be better

adapted for thoroughly effecting its object in the case with which I had to deal; and it may now be as well that I should explain specifically what that case is; since whatever I may advance has reference to that alone, and I make no pretensions to prescribe for others.

This estate lies on the western edge of the Yorkshire coal measures, at an elevation, for the most part, of not less than from 600 to 900 feet above the level of the sea, and within 8 or 10 miles of the crest of that great range of moorland hills formed here by the vast masses of the "Millstone Grit," which at this point, separating the counties of York and Derby from those of Lancaster and Chester, and prolonged on either side by one formation or another to the Scottish border and to the midland districts, has been called the Backbone of England. The surface is varied and steep, and there is nowhere any difficulty of fall or outlet. The soil of this region, generally, has been thus described by Mr. Charnock, in his Essay on the Farming of the West Riding (Journal, vol. ix. pp. 288-9):—

"By far the largest portion of the soil on this formation is of a strong character, resting on the ordinary subsoil of yellow clay, so general in the coal districts. The clay with its strong soils usually covers the valleys, and the entire rise in the lower swells, but in the more elevated places extending only a limited distance up the rise, where the sandstone comes through, and a friable soil commences, as though the aluminous particles had slipped or been washed down from the steeper inclinations, and formed the clay subsoil of the lower levels. At Woolley, Staincross, and Barnsley, these features are very perceptible; after which we meet with exceptions to this order in a considerable tract of the clay subsoils, interspersed with a saturation of light-coloured aluminous sand, and very wet, extending to Sheffield and up to Wortley, and thence forward with but little variation to the prominent point of Wharncliffe brow."—vol. ix. pp. 288-9.

The yellow clay thus mentioned, of qualities varying somewhat in closeness and depth, forms here, in fact, the almost universal subsoil. At a certain point, but not *always* within a descent of 4 feet, it is generally found to rest either on the rock, or on a shale almost entitled to that name, differing therefrom only in its laminated structure; compact as if it had been subjected to a hydraulic press from the beginning of the world; entirely impenetrable both to roots and water, and dry as a board when all above is soaking;—or on shales of loose and broken texture, pervious to both, and usually overflowing with the latter. These are sometimes interspersed with outcrops of the coal, and crossed by the edges of "throws" or "faults," which are generally observed to act as partial dams, retaining an accumulation of water, which, when they are pierced, finds of course a ready vent. Commonly at about 3 feet, or 3 feet 6 in. deep, some one of these beds is met with underlying the yellow clay; but occasionally it is necessary to lay the drains at 4 feet, without being

able to pass through it; or to carry them for a few yards at a still greater depth to reach an ascertained source of water; while at another time, the occurrence of the impenetrable shale above mentioned bars all farther downward progress, and proclaims it useless, even within 3 feet of the surface. Such is the general character of the ground in which the above-mentioned trials of various draining measures have been made; and where, effectually as we may have withdrawn the water from *beneath* the "yellow clay," our success in drying the soil *above* it has certainly not been uniform.

Now, if the evidence which we have had of similar operations in other quarters can be trusted, there is nothing in these circumstances to account satisfactorily for the failure. Clays as close and deep are positively asserted to have yielded all that could be desired to simple four-feet drains. In Northamptonshire, in Kent, in Sussex, in Oxfordshire, in Essex, and elsewhere, we are told of land of the stiffest texture—of clay almost uniform from the surface to a depth beyond that to which such work can be carried—undeniably dried by such means. Why, then, should we meet with so much difficulty where it only forms part of a more manageable series, and is not unfrequently itself of a less apparently stubborn nature?

It strikes me forcibly that the true solution of this question probably lies in an agency of which too little account has hitherto been taken by our otherwise able leaders and instructors in the science. Their attention has been exercised perseveringly upon diversities of soil: must we not bestow more of it upon those of climate? Its differences within these islands is confessedly great; let us inquire how they are likely to affect our results.

In order to secure the full effect of thorough drainage in clays, it is necessary that there should be not only well-laid conduits for the water which reaches them, but also subsidiary passages opened through the substance of the close subsoil, by means of atmospheric heat, and the contraction which ensues from it. The cracks and fissures which result from this action are reckoned upon as a certain and essential part of the process. A single passage from the pen of one of the ablest masters of the science will be sufficient to establish this point, though there is no lack of others. Mr. Parkes says, in the valuable and well-known essay in the fifth volume of the Journal (p. 145), that—

"A natural agricultural bed of porous soil resembles an artificial filter; and it is unquestionable that the greater the depth of matter composing such filter the slower is the passage of water through it. In stiff loams and clays, however, but more particularly as regards the latter earth, the resemblance ceases, as these soils can permit free ingress and egress to rain-water only after the establishment of that thorough network of cracks and fissures, which is occasioned in them by the shrinkage of the mass, from

the joint action of drains and superficial evaporation. These fissures seem to stand in the stead of porosity in such soils, and serve to conduct water to drains rapidly, after it has trickled through the worked bed. It is possible, too, that in deeply-drained clays of certain texture the fissures may be wider, or more numerous, in consequence of the contraction of a greater bulk of earth than when such soil is drained to a less depth. However this may be, it is asserted by several respectable and intelligent farmers in Kent, who have laid drains very deeply in clay and stiff soils, that the flow from the deepest drains invariably commences and ceases sooner than from shallower drains after rain."—vol. v. p. 155.

To give efficiency, therefore, to a system of deep drains beneath a stiff clay, these natural channels are required. To produce them there must be a continued action of heat and evaporation. If this action should be defective or uncertain, can the system be efficient in that form? and, finally, is any such action always to be expected?

Perhaps, without looking diligently into the statistics of this subject, most people are little aware of the extent of variation to which our English climate is liable. I invite the attention of my readers to a short consideration of it, as affecting the particular question now before us.

In the last Number but one of the Society's Journal was an essay of more than common merit, "On the Climate of the British Islands, and its Effect on Cultivation." Its writer, Mr. Whitley, of Truro, tells us (p. 7), that "It appears that the eastern counties, and the midland counties around Bedfordshire, have, as a whole, the highest summer temperature in England." Let us, then, to place the matter in a strong light before us, compare, as nearly as our means of information will permit, the climate of those portions of the kingdom with that of this district on the verge of the Yorkshire hills.

Mr. Whitley gives in the same essay a table, "Showing the Mean Temperature of each Month of Summer, and of the whole Year, at the Places therein mentioned." In this table the aforesaid particulars for Bedford are contained. There is no place, indeed, which is so situated as precisely to represent the other member of the comparison. Those offering the nearest approximation are Ackworth and Derby; but the former, lying about fifteen miles due east, well removed from the influence of the hills, and on the edge of the magnesian limestone, though somewhat nearer than the latter in respect of distance, has fewer points of essential resemblance. Derby, on the other hand, seated about 40 miles to the southward, upon the vast sandstone tract of central England, and not very far from the eastern base of the great elevated range to which we have before alluded, presents a general aspect analogous in many points to that of our own case. Its more southern latitude and greatly lower level of course im-

pair the completeness of the parallel; but it must be recollected that whatever corrections are to be applied on these grounds must be in a direction to *increase* the contrast, and therefore to *strengthen* the inferences which it suggests.

We will take Derby, therefore, and place it side by side with Bedford, viewing the latter as the representative of the counties lying around it, and the east of England; and there can be little doubt that our reasoning might almost with equal truth include the greater part of the southern and central tracts also; especially when the comparison is to be made, ultimately, not with the climate of Derby itself, but of a district like this, differing from it much more than theirs does from that of Bedford.

The following, then, are the statements to be compared:—

	Elev. in Feet.	Mean Temperature.												Year.	Summer Temp.
		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.		
		°	°	°	°	°	°	°	°	°	°	°	°	°	°
Bedford	..	38·08	41·6	45·26	49·89	58·16	61·11	64·31	62·61	58·03	53·46	45·26	41·77	51·64	62·68
Derby.	160	35·0	40·5	40·0	43·5	50·5	53·0	55·5	54·5	51·0	44.5	37·5	33·5	44·92	54·33

Let me now first direct your attention to the mean summer temperature of the two places. At Bedford it is 62° 68′; at Derby only 54° 33′; showing a difference of no less than 8° 35′ in favour of the former! Consider for a moment the effect of such a continued excess of temperature upon the moisture of the soil! But it must be farther recollected that this expresses a *mean* alone—first, between the extremes of the whole season, but, secondly, also between those of each night and day; and that the results of the *evaporating power* would depend more upon the *higher* extreme, or average *greater heat,* than upon the daily or monthly mean; such power being only temporarily checked or suspended, but in no sensible degree reversed or neutralised, by the cold of night alone, when there is no positive accession of moisture during that short interval. Now, this last condition is not only not to be assumed, but there is strong reason for believing it would interfere less in a climate of higher, than in one of lower, temperature. There are two other tables supplied by Mr. Whitley: first, of the fall of rain at various places; and, secondly, of the mean difference between night and day at six out of this number. If we take from these six, two known to belong to the list of drier climates, namely, Chiswick and Norwich, and two, Truro and Whitehaven, as undoubtedly included among the more humid, we find that, in proportion as the atmosphere exhibits the latter character, the difference be-

tween the day and night temperature declines, and in the opposite case there is the reverse effect :—

	Rain in Year.	Mean Difference between Night and Day.		
		June.	July.	August.
Chiswick	° 24·4	° 22·8	° 21·2	° 21·1
Norwich	25·5	18·5	17·3	16·8
Truro	44·0	13·6	11·4	11·8
Whitehaven	47·1	12·9	11·0	11·0

The consequence of this must be, that whereas, for instance, the difference at Chiswick in June amounts to 22°.8, while that at Whitehaven is but 12°.9 ; the *mean* temperature of the twenty-four hours (which must in each case correspond with the middle point between the two extremes), would in the wet district only fall short of the heat of day by 6°.45; while in the dry it would differ from it by no less than 11°.4. The numbers annexed to the other two places support the same conclusion. Now, when we were comparing the temperatures of Bedford and of Derby, we were speaking, as before observed, of the respective *means ;* and by the same rule, if there is any difference in point of moisture between the two climates, the greatest heat will exceed the mean in the drier, in a greater degree than in the wetter ; and since the mean at Bedford is 8°.5 above that of Derby, the *greatest* heat at the former must therefore exceed that at the latter in a still higher degree.

In the table given by Mr. Whitley, indeed, to record the fall of rain, it would appear that the result obtained at these two places is identical, namely 27 inches ; in which I cannot help suspecting some inaccuracy. It seems to be almost necessarily refuted by the mere fact of the difference of temperature. It cannot be supposed, even according to the rules laid down by Mr. Whitley himself, that the small interval of latitude alone would suffice entirely to account for the lower range of the thermometer at Derby ; nor can it be credibly ascribed in any great degree to the nature of the soil. What cause, then, remains but a greater proportion of moisture? This, indeed, may be said to act and re-act upon the climate. The falling rain is probably in most cases itself colder than the lowest strata of the atmosphere, and abstracts at once some heat. When fallen, the process of evaporation begins, and enormously accelerates that abstraction. In proportion as there is naturally any scantier supply of heat to make up the loss, this is the more felt in the decline of temperature, and the process also

continues longer; and as the fall of rain is usually the consequence of such relative differences of temperature in the atmosphere, this again tends to augment the normal moisture of the climate. Thus it may be inferred that the colder locality has to contend with a double disadvantage—on the one side of a feebler evaporating agency, and on the other of a larger amount of moisture to be evaporated. But be this as it may, there can be no reasonable doubt of an increment of rain when we carry the comparison forward to *this* district; and I do not hesitate to conclude that if a correction were applied to the difference of summer-heat between it and Bedfordshire with reference to this point alone, that difference would amount, at a very moderate allowance, to 10° in lieu of 8°. 5.

But, secondly, observe the remarkable difference in even a still more important element for our purpose—that of the *duration* of summer heat. The figures first quoted give the mean temperature of each separate month; now, taking the point which is conventionally marked on the scale of the thermometer as *temperate*, namely 55°, and comparing it with these statements, you will perceive that at Bedford it begins to exceed that limit in the month of May, and does not return below it till October, remaining above it for five months. But how different at Derby! The mean summer temperature there ranges below the same point throughout every month except July, and in that only passes it by a half degree.

It thus appears, that between these two places there is a difference of at least 8°. 5 in amount, and of four months in duration, of summer heat; and I think you will agree with me that this is not likely to be without a sensible effect upon the subject-matter of draining operations, and that it may afford a clue to some of the puzzling results which we have been striving to understand.

But it must not be forgotten that even this is not all. We took the case of Derby, not for its own sake, but as our own best, though imperfect, representative in this comparison. Its elevation above the sea, as stated in the foregoing table, is 160 feet; ours is nearer an average of 750. Let us then suppose Derby gently lifted from its smiling vales of Trent and Derwent, to a height of some 550 feet above them, borne off to the northward more than forty miles, and there lodged upon some ridge or slope at the said elevation—would, or could, its climate remain unchanged? And might we not at once conclude that, instead of a deficiency of 8°. 5, or even 10° in amount of heat, and of four months in its duration, such a site would exhibit a loss of evaporating power, as represented by summer temperature, of not less than 12° or 15°, compared with the wide, level, and lowland expanse of the east, centre, and south of England? that the mean would probably in

no one month surpass the assumed point? and that while these elements of atmospheric agency were thus reduced on the one hand, the fall of rain on the other, to be evaporated or discharged, would have to be expressed by perhaps half as much again as the 27 inches, which is stated to be its exponent at Bedford?

You have already recorded your conviction that such considerations as these cannot be neglected with safety in regulating the operations and improvements of agriculture; and I cite your words with pleasure, as lending authority and confirmation to my own.

"How can a fixed rule be laid down for the depth or the distance of drains, or the size of pipes, when one county has 25 inches of rain and another has 50 inches to be carried off by these drains? The difference is in fact more than this, for a large part of the downfall returns to the air from the surface. According to the most recent and trustworthy experiments published in this journal by Mr. Charnock, out of $33\frac{1}{2}$ inches of rain no less than 25 inches are evaporated, $8\frac{1}{2}$ inches only reach a depth of 3 feet, and therefore pass through a drain. This was in Yorkshire; but at Kendal there fell 54 inches of rain. The evaporation there, however, would not be more, but less, because the air being moister must dry what is exposed to it more slowly, and the evaporation would not exceed, probably fall short of, 21 inches. There remains, therefore, for the drains 33 inches depth of water in this case, $8\frac{1}{2}$ inches only in the other—four times as much in Cumberland as in Yorkshire. Yet, hitherto, if a man living in Oxfordshire said that inch pipes would drain his land well, a voice from Ayrshire might exclaim, that it was absurd to use less than $1\frac{1}{2}$ inch pipe, which he found far the best. Yet the smaller pipe might be more competent to do its duty in one place, than the larger one in the other."

"Henceforth, in speculations on the agriculture of the country we must never lose sight of our material variations in climate."—vol. xi. p. 394.

But I hope that by this time I shall have succeeded in carrying conviction upon the point also into the mind of the most determined sceptics, if any such there be.

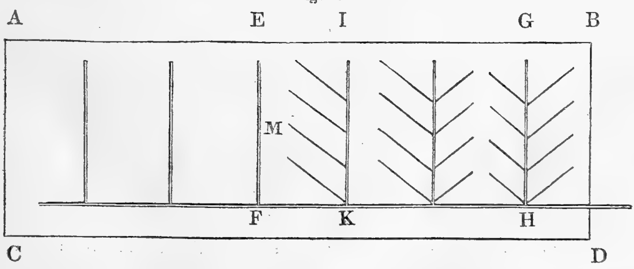
Now let us recur to our exposition of the specific case which led us into this investigation. If, as Mr. Parkes, and other authorities say, the contraction and opening of stiff clays by the action of atmospheric heat is necessary to the efficiency of deep drainage in such soils, and if, as I think we have demonstrated, and as, indeed, in these parts we know by experience, such process cannot be reckoned upon in ordinary years, and indeed can scarcely be said to occur, effectually, more than once in a quarter of a century, it seems indispensable to devise some system which may serve to secure the benefits of deep drainage without its help. Now the surface-soil, and generally the upper portion of the ground to a certain depth, is more or less friable and pervious, and could be easily relieved of its water long before this could under any circumstances filter through its bed of clay.

If, therefore, we draw off effectually and constantly the bottom water from beneath the clay, and from its substance, as far as it admits of percolation, and by some other means provide a vent for the upper water, which needs no more than this facility to run freely, there seems good reason to suppose that the object may be completely attained, and that we shall remove the moisture from both portions as effectually as its quantity and the substances will permit. Acting upon this view, then, after due consideration, I determined to combine with the fundamental 4-feet drains, a system of auxiliary ones of much less depth, which should do their work above, and contribute their share to the wholesome discharge, while the under current from their more subterranean neighbours should be steadily performing their more difficult duty.

I accomplished this by placing my 4-feet drains at a distance of from 18 to 20 yards apart, and then leading others into them sunk only to about 2 feet beneath the surface (which appeared, upon consideration, to be sufficiently below any conceivable depth of cultivation), and laying these at a distance from each other of 8 yards. These latter are laid at an acute angle with the main drains, and at their mouths are either gradually sloped downwards to the lower level, or have a few loose stones placed in the small interval between the two, sufficient to ensure the perpendicular descent of the upper stream through that space; which can never exceed, or indeed strictly equal, the additional 2 feet.

The result surpassed, and has continued to surpass, my most sanguine anticipations. When I first tried the plan I was draining a small grass field, containing much of the usual yellow clay, and so wet that at one end of it there was a spot permanently supporting a small bed of the *Caltha palustris,* or marsh marigold, which it is well known grows only in genuine swamp, where it can enjoy standing water on the surface. The following little diagram will show more clearly the precise form and nature of the case.

Fig. 1.



The deep drains had been laid in this case 16 yards apart,

and 3 feet 6 inches in depth; and I first introduced the auxiliary drains into one half of it as E, B, D, F. Before the whole field was completed I had an opportunity of examining it after abundant rain, and so remarkable was the effect that, in stepping over the line E F, from the plain surface between deep drains alone to that furnished with the auxiliary system, I could compare it to nothing less than passing to dry from undrained land. The success of this experiment induced me of course to extend the practice. I have since adopted it almost universally, and I believe I may say with the same invariable result. The foremen of my drainers are unhesitating in their testimony to its efficacy; and I believe I may refer to Mr. Graburn, who has twice since inspected my works, as Assistant Commissioner for the Government advance, for a no less favourable judgment. I believe that in no instance where he has examined ground of mine under this system has he found any reason to doubt the completeness of its performance. In one or two cases, where the common method had still left the soil wet, we added the shallow or 2-foot drains to the deep ones upon the same plan, and had the satisfaction of witnessing an apparently permanent cure. I was, however, still anxious for an opportunity of observing the action of these drains myself more closely, since there have been various statements made as to the total inutility of shallow drains by the side of deep ones; which are said to abstract the whole flow of water, and to leave their more unpretending neighbours dry; I therefore ordered two or three of the 2-feet drains to be opened for that purpose in a field which had been drained for some weeks, and to be left so that the pipes might be investigated in several places. After some heavy rain I took occasion to examine them, and I can affirm from ocular inspection that, in this case, at any rate, they were each of them conveying a brisk little stream to the main channels. Nothing could be more satisfactory than this expressive evidence; and it farther strengthened the convictions which I had imbibed from other sources; for, let it be recollected, that in the absence of these outlets, that same water would have been dammed up in the soil until, without the aid of cracks and fissures, it had been able to filter through the clay bed beneath. How long it would have required satisfactorily to accomplish this process we may conjecture, though we cannot determine.

But I go one step further. Supposing that this filtration were a more certain process, and that the regular action of a good parching summer rarely failed to secure and establish it, is there nothing gained in the *immediate* drying of the land by means within our own command at any season? If it is drained, as much must be, in autumn and winter, is there not something achieved in laying it dry for immediate use during those quarters

of the year, and in the coming spring? If the success of the work is to depend upon the summer heat, the soil can profit little by it for some nine months, at the least, of the most important in the agricultural year. If the result is attained at once, it may be said that a whole farming season is saved.

But now comes the critical question of cost. These advantages, even if realised, may be too dearly bought; and I am bound to show that their price can be brought within ordinary limits. I own I felt this strongly at all times, and I have accordingly weighed the matter with care. I think I can show that there is nothing out of proportion with the object to be attained.

In the first place let me point out a few particulars, in which I am enabled, by the very nature of the system, to economise. When I place deep 4-foot drains, merely, on the one hand, to tap the lower sources—the springs and the loose watery shales—and to withdraw continually the moisture which, by however slow a percolation, makes its way downwards through the incumbent clay beyond the reach of the shallower system, and on the other simply to serve as conduits for the receipt and transmission of that which flows from those above, I am able to neglect all reference to their drainage of the surface in deciding upon their distances. I have no doubt that, under these circumstances, their intervals may be made safely greater. I should hesitate, in any clay, to separate deep drains so far as 60 feet, if their business were to drain the surface; so I believe would most authorities. But I feel satisfied that for the more limited purpose it may be safely done; and I have every reason to believe that my experience has proved its sufficiency. In the ordinary method 10 or 12 yards are the distances of which we usually hear for deep drains; and they seem to be as great as can be expected to render them efficient in stubborn soils. Now it must be remembered that the expense of cutting increases at a greater ratio than the depth; and if for half their number, therefore, we substitute others of half the depth, the difference of cost would be less, by more than the same proportion.

But, again, I have, I believe, like many others, always hesitated to lay my deep drains with pipes of one inch diameter. Though it is true, I admit, to demonstration that these small channels suffice to carry off an almost incredible amount of regularly flowing water, still, considering the extraordinary supplies which they may be sometimes called upon to convey, and the difficulty and expense which, if ever seriously overcharged, must be incurred in opening and repairing or relaying them, I have thought the additional cost of a little larger diameter was well repaid by the smaller risk. The same may be said of any trifling chance obstruction; which would take a greater effect in

the smaller than in the larger pipe, by more than the mere difference of diameter.

But with respect to the auxiliary drains the case is altered. There I have no misgiving as to the inch-pipes: they have a less mass of soil to relieve, and necessarily a shorter course to run, being limited by the intervals between the deeper; and if by accident any stoppage should occur, there is no comparison between the two cases in respect of the labour and difficulty of a remedy. In all that length of drain, therefore, in which a 2-feet depth can be substituted for a 4-feet, the difference in cost between the 1-inch pipe and the 2-inch can be safely spared.

Now these are material compensations in the question of cost. When I first projected the plan of which I have been speaking, I had great apprehensions on this vital part of the subject. It was obvious that it could not be executed without an additional extent of *linear* cutting, and I had great fears that I should not be able to bring it within the moderate limits which are the necessary condition of practical success; but upon closer examination the difficulty shrunk into much narrower dimensions. In ground which it is possible to dry by simple deep drains at wide intervals, the object may no doubt be rather more cheaply attained; but then such ground needs no farther aid. Wherever, on the other hand, deep drains alone would be imperfectly efficient unless at narrow distances, the compensations I have above explained have enabled me even to reduce my outlay to a lower point than would have been necessary to secure it under such a system.

In my district I have always thought that if I could bring the expense of my draining operations within 5*l.* an acre I might be fairly satisfied, and, I believe, my tenants too; for that there is little, if any, stiff land converted from wet to dry which will not largely repay such expenditure. My readers, however, will probably, for the most part, exclaim that I am extravagant in my scale, and that the work may be, and ought to be, done much more cheaply; you, yourself, have given us such details and estimates of cheap draining that I fear you will be one of this class of critics. There may be some few points perhaps in which my established operations might be capable of still stricter economy, which has been unattained from accidental circumstances; but the main clue to the difference of cost is the difference in the price of labour. Throughout the greater part of the agricultural districts from 8*s.* to 10*s.* per week have been considered good average wages, and would now probably be somewhat above the usual mark. Here, however, a good labourer until lately could command 14*s*, and even now can obtain 12*s*. This then is a cardinal difference. The remuneration of piece-work must of course

be measured in proportion—not to mention the actual rate of superintendence; and the excess of cost in the item of labour, therefore, may be assumed at not less than 40 per cent.: I only wish those who would be disposed to cavil at my statements of cost to bear this in mind.

Soon after I commenced my present system, one of my foremen suggested that the most convenient mode of executing it would be to place the auxiliary drains not converging on *both* sides into the deeper, as at G H in fig. 1, according to my first intention, but on *one* side only of each 4-foot drain, as at I K, whereby the trouble of laying them out would be diminished; the labour of effecting the junctions, either by lowering the ends or by placing some open materials under them, and the trifling difficulty even of finding such materials, would be halved. The reasons seemed good, and I adopted the advice, which I think the result has justified. My method, therefore, now is (after having examined each special case, and ascertained that it is applicable), to lay my deep drains with $1\frac{3}{4}$-inch pipes, almost universally at 4 feet deep and 20 yards apart, and to incline the shallow into them in the intervals, but all on *one* side only of each of the former, at 8 yards *direct* distance from each other, and laid with inch-pipes at a depth of 2 feet, which is well below the workable soil, and beyond the reach of any supposable cultivation.

On these assumptions, then, how stands the calculation?—At 20 yards distance the number of drains contained within the area of a perfectly regular acre would be strictly eleven, each of 22 yards long, making an entire length of 242 yards, or $34\frac{1}{2}$ roods of 7 yards, the ordinary measure in this district; the *rod* of $5\frac{1}{2}$ yards being almost unknown. Our usual payment for cutting and filling, per rood of 7 yards, upon an average of mattock or spade work, in good or bad ground (barring hard stone), has been 1*s.* 3*d.* This gives the sum of 2*l.* 3*s.* 1*d.* for the cutting and filling of the 4-foot drains, per acre.

Now let us suppose, to simplify the case for the moment, that the minor drains are placed at *right angles* to the above. It may be assumed that it will be unnecessary to carry them entirely across the 20 feet intervals, because they and the deep drains together will certainly be competent to dry a certain distance between them at the opposite side from their junctions, as at M, fig. 1. If we can place these minor drains at 8 yards apart, we may safely allow the half of this distance at those points. In the supposed case, then, each of these 2-feet drains would be 16 yards long, and there would be one at every 8 yards along the length of the deep ones. This will be found to give about 30 such drains to the acre, measuring altogether about

480 yards, or almost exactly 69 roods of 7 yards each. But these smaller drains can be executed, even with us, at $3\frac{1}{2}d.$, instead of the 1*s*. 3*d*. which we were obliged to calculate before; and the cost, therefore, of these 69 roods will be 1*l*. 0*s*. 1*d*., almost to a fraction, showing, when added to the previous sum of 2*l*. 3*s*. 1*d*., a total of 3*l*. 3*s*. 2*d*. for the cutting and filling, per acre, upon this combined plan.

To this we have to add that of the pipes, which, taking them at an average of 12 inches in length, is easily reckoned. The deep drains have a total length, as above, of 242 yards, corresponding to 726 such pipes, of $1\frac{3}{4}$ inch bore, which if charged at 15*s*. per 1000 (I think a full price), would amount to 10*s*. 6*d*. as nearly as may be. On the other hand, the inch-pipes laid in the 480 yards of shallow drains would be 1440; and these, at 12*s*. per 1000, would cost about 17*s*., so that the whole outlay would stand thus:—

	£.	*s.*	*d.*
4-feet drains, cutting and filling . . .	2	3	1
2-feet ditto	1	0	1
	3	3	2
$1\frac{3}{4}$-inch pipes	0	10	6
1-inch ditto	0	17	0
Making a total of . . .	£4	10	8

But it must be recollected that this is in some respects an extreme estimate. In the first place, I think it probable that the rates of measure-work are now rather too high, even for us, as they certainly are for other districts. Next, the calculations are the rigorous result for a full acre, without any allowances. Now there can be no doubt that upon an average, taking into account the portions of land safely left at the heads of the drains, and those served by the main channels into which all pour, the real lengths are always somewhat under these numbers. On the other hand, a trifle would have to be added for the cost of pipe-laying and superintendence, and for the price of the few still larger pipes necessarily used in the common outlets; and we cannot be far wrong in allowing these items to balance one another on each side, with the exception of the rate of labour. On this hypothesis, then, the expense per acre on this system amounts only to about 4*l*. 10*s*. 6*d*., even by the scale assumed under that head, which I dare say you and many others will at once condemn, and which we may admit could not sustain a scrutiny as a general criterion.

But our argument will be just as good if we make our comparisons by the same scale. Let us, therefore, apply it to a few varieties of the ordinary method.

I know from my experience, from my observation, and from the

testimony of others, that deep drains in strong subsoils and moist climates will not always successfully dry the surface at wide distances. It would be idle to place them in such situations, for the most part, at more than 10 or 12 yards of interval. I have indisputable cases of failure even at these. Let us, however, take those two—

	Total length of 4-feet Drains in roods of 7 yards per Acre.	Cutting and Filling at 1*s.* 3*d.* per Rood.	1¼-inch Pipes in ditto at 15*s.* per 1000.	Total Cost of ditto per Acre.
		£. *s.* *d.*	£. *s.* *d.*	£. *s.* *d.*
At 10 yards. .	69	4 6 3	1 1 6	5 7 9
At 12 yards. .	57½	3 11 10½	18 0	4 9 10½

The elements in both sides of this comparison are the same; and it will be seen that though the latter is lower than the previous calculation by not quite 1*s.*, the former exceeds it by 17*s.* 1*d.*, and indeed transcends the limit considerably, within which such work should if possible be kept, with a view to profitable improvement.

I have supposed above, for the sake of convenience in calculating the compound system, that the minor drains were to be drawn at *right angles* to the deeper. Now this is clearly an inadmissible arrangement for many reasons. Almost the only serious objection which the plan appeared to me from the outset to involve, was, the necessity for placing the former at *some* angle to the latter, and therefore not strictly in the direction of the fall. This might be a more troublesome difficulty where the fall is scanty; with me it is superabundant, and I cannot say that I have ever observed any real evil or imperfection to arise from it in practice. But as a general rule I believe cross and oblique draining to be—for deep drains at least—rightly exploded. I therefore bestowed some attention on the possibility of drawing the shallow drains *parallel* to the deep ones, but at intermediate distances. Reflection, however, inclined me against it, for these reasons; that in the first place, unless we took for granted that the deep drains would perform the work on the surface efficiently for at least several yards on each side of them, an assumption which in such cases could be but doubtfully made, we should impose upon the shallow either the necessity of acting to an unreasonable distance, or should be obliged materially to increase their total length and expense by augmenting their number; and, secondly, that whereas I have no hesitation as to laying such drains as mine—mere auxiliaries of a regularly limited length—with the inch-pipes, I should not hazard it with quite the same confidence if they were drawn out to the full length of the deeper. Mr. Parker has, I believe, determined

the extent of surface which can be safely assigned to be dried by a certain length of channel of a stated bore, and adapts his practice to the scale; and it is obvious that if the length and distance were made to exceed that correctly defined by such a rule, it would be necessary to relinquish the advantages gained by the use of the small pipes. Still it might be very possible in many cases to introduce such a modification as the above with utility; and as there would be at least a saving in the reduced number of the *junctions,* perhaps with little, if any, difference of cost.

At right angles, however, as we have supposed in the above calculations, it is at least clear that the drains could not be rationally placed; and it may very naturally be inferred, that if we depart from that condition and arrange them at any other angle, our reckonings and estimates would no longer hold good. But it is a somewhat remarkable result of an investigation of this question (the full explanation of which, to spare my ungeometrical readers, I will consign to the modest seclusion of a note), that at whatever angle these side drains are placed,—*the direct distance of their farthest ends from the deep ones into which they fall,* and *the direct distance between themselves,* being both fixed at any determinate measure,—the *total length of the whole series of such side drains will remain the same.* This leaves us entirely at liberty to select the angle of junction which we may deem most expedient for other reasons. It is desirable, on the one hand, to bring their lines, as far as we safely can, to approach that of the general slope, but, on the other, not to make their individual lengths too great. It would seem, therefore, that it could scarcely be right to make their angle greater than 45°, nor less than about 20° or 30°. It will be seen by the following table what are the *lengths* of each small drain, and what the distance *between their junctions in the*

Angle of Junction.	Cosecant of Junction.	Length of Drains in Yards.	Distance between Junctions in Yards.	Number of Drains per Acre.*
°	°	°	°	°
45·0	1·41	22·56	11·28	21·4
40·0	1·55	24·80	12·40	19·5
35·0	1·74	27·84	13·92	17·3
30·0	2·00	32·00	16·00	15·0
25·0	2·36	37·76	18·88	12·8
20·0	2·92	46·72	23·36	10·3

* Any one may ascertain these quantities for himself upon other data, by simply multiplying any chosen length and distance of the secondary drains (measured in the manner already pointed out) by the value of the cosecant to any proposed angle of junction; as in the above table.

deep one measured along the latter (which determines their number), upon the suppositions, first, of their being placed at either of the angles, varying by 5°, from 45° down to 20°; and, secondly, of the above fundamental distances being fixed, as in my practice, the former at 16 yards, the latter at 8.

But I give the table only as an illustration of the fact. When once this is ascertained and established, the practical result cannot fail to be attained empirically by the actual laying out of the work, if properly arranged; and the director may adapt his system to his case in confidence that by any variation in this respect his outlay will remain unaffected.

I have thus, I think, shown that, whatever may be thought by others of the system which I have myself pursued, and have here undertaken to expound, it is at least capable of being carried into practice within reasonable limits of expense, and is, nevertheless, susceptible of varied adaptation in its elements to the inevitable diversity of actual cases. A certain measure of such pliability is indeed a necessary ingredient in the intrinsic value of any plan of the kind. If it were usefully or easily applicable only to circumstances essentially of an exceptional nature, I should scarcely have thought it worth while to bestow so much pains or words upon it, or to make so considerable a demand upon your indulgence and that of my improving contemporaries; but there is nothing that can be properly called exceptional in my case. There are assuredly a multitude of districts and localities in these islands which share with this in the characteristic features of soil or climate, or both, to which I have invited attention; many in which they are still more marked and more powerful in their agency. Whether those who have to deal with them will think that there is enough in what I have said to induce them to try my practice, I of course neither presume nor wish to decide. I have already before declared that I prescribe for no one else, content with detailing and explaining what my own experience has taught me for my own interests. If any deem what I have recorded deserving of attention, it will be for them to determine, after all, how far it is likely to bear upon their exigencies; I shall be quite satisfied with having contributed something to the more complete discussion and elucidation of the first and surest of all agricultural improvements; though I shall not be insensible to a farther gratification if it should prove in any degree more immediately and directly serviceable. With the view of laying the whole subject before you in such a manner as to give it a fair exposition, and not to exclude this possibility, I have allowed my disquisition to run to a greater length than I originally designed; and, I am afraid, so far as to try your patience. But I doubt whether I could have satisfac-

torily performed my task within straiter limits; and now, with an invocation of all the indulgence it may need from yourself and others my possible readers, I commend it to your joint and separate notice, for the extraction of whatever good it may really contain.

Believe me yours very truly,

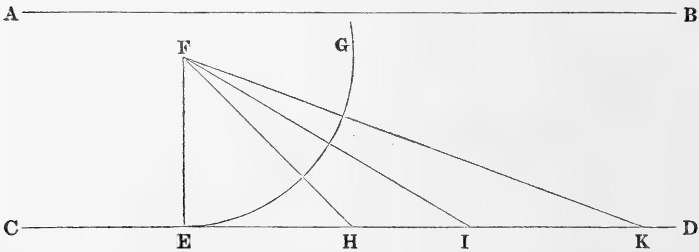
WHARNCLIFFE.

Wortley, Sheffield, April, 1851.

NOTE.

Let A B or C D be supposed to be two of the parallel deep-drains placed at any distance (say 20 yards) asunder. Then if the smaller drains are extended from C D (at whatever angle) to reach to within one-fifth, or 4 yards, of the opposite deep-drain, A B; their farther ends will be at the constant distance of 16 yards from the line C D. Let the line F E, at right angles to C D, be taken to represent that distance; and draw from the point F the lines F H, F I, and F K, at any angles, say respectively of 45°, 60°, and 70°. Then the inner, or acute

Fig. 2.

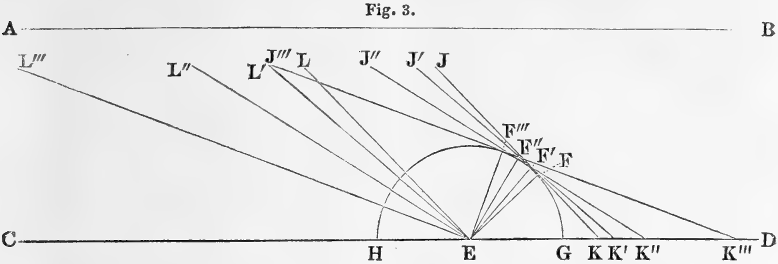


angles at H, I, and K will be the complements of these, or respectively 45°, 30°, and 20°; and it is obvious enough that, as these latter angles diminish, the length of the intermediate drains must increase. Now, if we draw the circular arc E G with the radius F E, it will be seen that the lines F H, F I, and F K, become the secants to the angles at the point F; or, which is the same thing, the co-secants to their complements, the angles at the points H, I, and K; and therefore so long as the distance F E remains constant, the length of the several branch drains so drawn will vary as the *cosecant of the angle at their junction* with the main drain C D, corresponding to the radius F E.

This, then, being the law of variation for their *lengths,* it next becomes necessary to determine that for their *number,* assuming

that the direct distance between any two of them, measured at right angles to their parallel directions, is a fixed quantity.

Fig. 3.



For this purpose let A B and C D again represent a pair of the deep drains bounding an interval of 20 yards in width, and let the auxiliary drains have their outlets along the line of C D, and be carried to within a certain distance, say 4 yards as before, of A B. Then the direct distance of each of those ends from C D will be, as before, 16 yards, a constant quantity. Now, suppose that from any point, E, a line be drawn at an angle of 45° to the point L, at 16 yards from C D, and that, from E also, a line, E F, be drawn at right angles to E L, and corresponding to a given distance, say as before of 8 yards. Then a third line J K, drawn through F, and parallel to E L, will represent the next auxiliary drain laid at an interval of 8 yards, and at an angle of 45° with the main drain.

Now, it is obvious that the distance E K between the junctions on this last line must be larger than E F the *direct* measure of the interval between the small drains, in all cases except where the primary and secondary lines are at right angles to each other; and that if we similarly draw other pairs of lines at smaller angles, as one at 40°, at 30°, or at 20°, these distances will continually increase, as E K′, E K′, E K‴, as the angle diminishes, in comparison with the perpendicular representing the true measure of the interval between these parallel lines: and as the number of the points of junction must diminish in proportion as the said distances increase, the length of these segments of the line C D will determine the number of the secondary drains in a given length of the primary. Now, if from the point E we describe the circle H F G, with the lines E F, E F′, &c., which are assumed all equal, as radii, the segments E K, E K′, &c., become the secants to the several angles F E K, F′ E K′, &c., and therefore cosecants to their complements, the angles F K E, F′ K′ E, &c., which are the angles of junction, as before. But the number of these minor drains must vary inversely as the distances between their origins along the main

line; and therefore we conclude that their number will vary inversely as the cosecant of the angle of junction.

We have therefore the *length* of each of these auxiliaries, and their *number*, varying, the one directly and the other inversely, at the cosecant of the same angle; and consequently as the one increases the other necessarily diminishes in exactly the same proportion; and whatever be the angle chosen, the total length to be cut remains the same, so long only, be it always remembered, as the *perpendicular* distances between themselves, and those of their upper ends from the line of the primary drain with which they are connected, remain constant at any certain measure. Or, to express it more concisely in a simple mathematical formula, if l signify their separate lengths, and n their number, while r and r' denote any fixed measures representing the above two distances, and θ the angle of junction, then the total length of the auxiliary drains, or $n\,l$, will vary as $\frac{r \times \text{cosec}\,\theta}{r' \times \text{cosec}\,\theta}$, or $\frac{r}{r'}$, a constant quantity; and therefore will remain always the same; and if L be taken to express the total length of the deep drains in the acre, at 20 yards, or any other assumed distance apart, $L \times \frac{r}{r'}$ will represent the actual whole length of the shallow combined with them, upon this scheme, at whatever angle of junction they may be placed.

III.—*On Abortion in Cows.* By J. Barlow, V. S. Edinburgh Veterinary College.

Prize Essay.

Abortion (from Aborior, to be barren) is the term used to imply an expulsion of the contents of the gravid uterus of any animal before the usual period of gestation is completed. This period, or time included between the process of fruitful connection of the female with the male and the act of natural parturition or birth of the young, differs in duration in various animals. In the cow the time of gestation is commonly considered to be forty weeks. Much difference, however, is seen to exist in various cows; it is no unusual circumstance for some to exceed this period by one, two, or even three weeks, and for others to calve ten days or a fortnight before its expiration, all these variations being perfectly consistent with health both of mother and young.

M. Tessier, in a report founded on forty years' observation, and presented to the Royal Academy of Paris, says, that in 1131 cows which he observed, the longest period of gestation was 321

days, or 46 weeks within one day; that out of 577 individuals no fewer than 20 calved beyond the 298th day, and that the shortest period was 240 days. Earl Spencer, in the "Journal of the Royal Agricultural Society of England" for 1839, considers the average period of gestation, as noticed in 764 individual cows, to be 284 or 285 days; but 310 calved after the 285th day, 3 went to the 306th day, and 1 to the 313th. A cow pregnant with a male calf is more likely to exceed the 40 weeks than she is with a female. This is shown in Earl Spencer's observations; he found that among calves born between the 290th and 300th day, there was a preponderance of males in the proportion of 74 males to 32 females. It has been found in the human female, as well as in the cow, that the period of the first gestation is frequently shorter in duration than subsequent ones. This probably depends on the uterus of a young female not being adapted for that amount of expansion of which it is rendered capable by repeated pregnancy. Calves born before the end of the seventh month seldom survive, even if born alive, and it is rarely desirable that they should live if born before the end of the eighth month, as their weakness and diminutive size render them comparatively valueless.

The cow usually produces but one calf at a birth. Very numerous instances occur, however, in which twins are born, and if these be one a male and the other a female, the latter is generally (and according to popular opinion in some districts, invariably) incapable of breeding. Such females are called *free martins,* and are evidently the same animals which Columella (lib. vi.) calls *tauræ,* probably from their approximation in certain points to the formation of the bull. It is now well known that many of these females are capable of breeding. Recorded cases, proving this to be the fact, are to be found in the "Philosophical Transactions," vol. lxix. p. 289; in Professor Owen's edition of Hunter's "Observations," 1837; and in the "Farmer's Magazine" for November, 1806. Occasional cases occur in which cows produce three calves at once; and in the "Nouveau Bulletin des Sciences" an account is given of nine calves having been produced at three successive births by one cow.

Although abortion is the term which the professional man employs to signify a premature expulsion of the uterine contents, yet, as applying to the cow, numerous other names are in daily popular use to signify this condition. Some of the most common are these:—*Slipping calf, slinking calf, picking calf, casting calf,* and *warping.*

Abortion in the cow may take place at any period of gestation, but is most common between the ninth and fifteenth weeks. It may occur before the germ or ovum, from which the future animal is formed, has assumed any of its permanent characters,

and when it is so minute and cellular in structure as to be hardly observable by the naked eye. It may also take place when the embryo, or first rudimentary animal outline, is barely recognised among the contents of the uterus, and it may be deferred till the various organs and members of the fœtal body have attained more perfect development. In the human female, if this expulsion take place during the first sixteen weeks of gestation, it is called *abortion;* if between the sixteenth and twenty-eighth week, it is termed *miscarriage;* if between the twenty-eighth week and the full period, it is considered *premature labour.* This distinction in terms is not observed in reference to the lower animals.

Extent of the Prevalence of Abortion.—From various inquiries which have been made, and from the statements of travellers and other persons competent to speak on the subject, it seems that among the vast herds of wild cattle inhabiting large tracts of country on the continents of the old and new world, abortion is unknown. In those mountainous districts of our own country which we have visited, more especially in Wales and Scotland, where small black cattle (although domesticated) are less artificially treated than the cows of richer districts in other parts of the kingdom, abortion, except as an accidental circumstance, is almost unheard of. It is also interesting to notice, that the pregnant human female, although exposed to the apparent hardships and discomfort of a savage life, is very rarely subject to abortion. Women, too, in our own and other countries, in the lower ranks of civilized society, are, on the whole, infinitely less liable to abortion than those of their sex who participate fully in the luxuries and artificial refinements of life. These facts are of great interest, and, as we shall presently find, although they do not prove what the causes of abortion are, yet, on the other hand, they instructively show (what is of great value in medical evidence) that while one class of animals is exempt from the operation of the causes in question, we must expect to find that such causes act, and are to be found in special connection with some peculiar conditions under which the affected animals are placed.

With the exception of the human female, there is not any other animal so subject to abortion as the cow. In some seasons, more especially during a wet autumn, or in the early months of spring, it is of such extensive prevalence among large stocks of cattle as fairly to be considered an epizootic disease. The dairy counties of England and Scotland have occasionally afforded striking illustrations of this fact, as cows over large districts of country have cast their calves without the apparent existence of any visible cause. At other times there seems a singular indisposition in cows to conceive (or "hold to the bull"), and the œstrum or heat continues to recur each three weeks or month during the season. Various continental authors supply us with

numerous cases, illustrating the epizootic character which abortion sometimes assumes. We may especially refer to the statements of M. Barruel, V.S., in the "Journ. Théor. et Prat.," 1832; to Chabert, in the "Instructions Vétérinaires," in which publication we are informed (tom. vi. pp. 130, 131, 137) that in 1782 the cows of Granvilliers aborted in consequence, *it was supposed*, of the heat of the preceding summer. The cows in Beaulieu aborted in 1789, in consequence, *it was supposed*, of the wet weather. In 1784 all the pregnant cows and mares aborted at Châlons; and the cows at Bournonville did the same in 1787.

In every season, and under every variety of circumstance, there are occasional cases of abortion met with in particular stocks of cows; but if there be a continued recurrence of this year after year in the same place (as is unhappily often the case), we may generally find it connected with some local cause. A cow which has cast her calf one season, is very likely to do the same in the pregnancy or year succeeding. If several cows among a stock have cast calf nearly at the same time, and if, on again becoming pregnant, they are allowed to remain together and in company with other pregnant cows, it very generally happens that for the most part they not only abort again, but more of their companions, advanced to about the same period of gestation, will slip calf likewise. Next year, if no precautions are taken, matters become worse; and in a few seasons more, abortion to a destructive and uncontrollable extent is the pest of the farm. Where this state of things has existed for years together, it is not an uncommon circumstance to find that the farmer will entertain the most absurd opinions regarding its causes and continuance. As a means of prevention, he will nail horseshoes over the doors of his cowhouses; bury the aborted calves with great ceremony, and under the observance of mysterious incantations; keep goats among his stock, or not allow his cows to take bull unless under a favourable "sign of the moon." A man who has observed a disease making yearly a steady and destructive progress among his cattle, who never adopts a single effective precaution which science and right reason suggest to prevent its extension, is just the person to fall a victim to dangerous and even superstitious ideas.

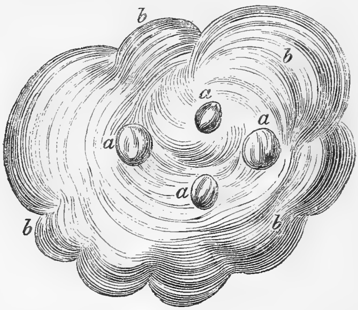
Abortion occurs among animals of all ages, and though sometimes most common in those pregnant for the first time, it is, on the whole, quite as frequent among cows which have had two or three calves. An animal which does not become in calf until she is four or five years of age, is more subject to abortion than if she took the bull earlier. Bakewell, the eminent breeder, was in the habit of delaying putting his cows to the bull until they were three years old, and many of them failed to carry their calves.

(See "Farmer's Magazine," vol. iii. p. 156.) Cows, which for months together have repeatedly failed to conceive, although they have been regularly in heat and have had connection with the male, are very liable to abortion on conception taking place.

Preparatory to a further consideration of the subject, we introduce here a very short account of the structure and uses of those generative organs of the cow which are most concerned in the reproduction of the species. These consist of the *ovaries, or female testicles, fallopian tubes, uterus* (*womb or* "*calf-bed*"), and *vagina* (all situated in the interior of the body), and of several parts placed outwardly, called the *vulva.*

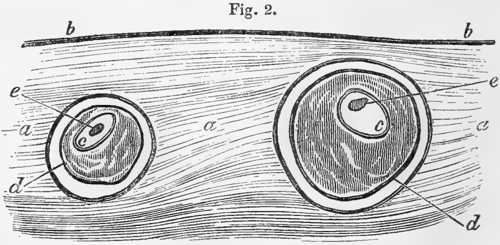
The ovaries (ovaria), fig. 1, so called on account of the minute ova, *a a,* or egg-like cells which they contain, the essential reproductive organs in the female, are dense, greyish coloured, shining bodies, about the size of a pigeon's egg, two in number, and are placed one on each side of the body somewhat behind, and lower down than the kidneys. They are attached loosely to the sides of the uterus and neighbouring parts by folds of a membrane called peritoneum, which also lines the whole of the interior of the belly; the same membrane likewise gives them a strong outer covering. Under the peritoneum they have a still denser envelope, which is continued into the substance of the organs dividing them into numerous compartments of small size, filled with blood-vessels, a connecting medium, and the *ova, eggs,* or *germs.* The ova are so minute as to render their structure incapable of being fully made out by the naked eye; but when sufficiently magnified, they are found to be essentially cellular in

Fig. 1.



Ovary. *a a a a,* Prominences caused by ripe ova approaching surface. *b b b b,* Situations where ripened ova have burst.

Fig. 2.



Section of portion of Ovary magnified, containing two Ova, enclosed in their Graafian vesicles. *a a a,* Stroma, or substance of Ovary. *b b,* Its covering of Peritoneum. *c c,* Ova, contained in their Graafian vesicles, *d d,* which each consist of two layers. *e e,* The Nucleus.

composition. They are contained in sacs called Graafian vesicles, *b b*, fig. 2, which are surrounded by the substance or stroma of the ovary, *a a a*. They consist, *c c*, of an outer part or wall containing a quantity of fluid, within which floats a small body or nucleus, *e e*. These minute ova are formed at an early period of life, but only attain their full size or development when the female is of sufficient age and size to propagate her species. At this time, called the period of puberty, the ripened ova, *d*, fig. 3, approach and burst through the surface of the ovary, *c*, and pass to the uterus—a process which takes place in the barren cow at every period of heat, and is accompanied by a desire for sexual intercourse with the male. If she be allowed to have connection with the bull, the male seed, by coming in contact with the ovum or female germ, establishes the condition of conception.

Fig. 3.

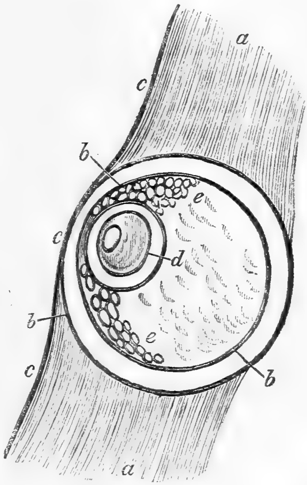


Diagram showing magnified ripe Ovum contained in its Graafian vesicle, lying close upon the outside of the Ovary and just within the Peritoneum, through which it is ready to burst. *a a*, Substance of Ovary. *b b b*, Graafian vesicle, composed of two layers. *c c c*, Peritoneum. *d*, Ovum, contained in its proper coverings. *e e*, Cellular matter which forms round ripened Ova to facilitate their passage from the Graafian vesicles.

The fallopian tubes, or oviducts, are two in number,—one, in connection with each ovary, is situated between the latter organs and the uterus. They are, *a a*, fig. 4, very tortuous, and are composed of a tissue possessing contractile powers, are lined by a soft moist membrane largely supplied with blood at certain times, and externally they are partially covered by peritoneum. Each tube opens into its respective side of the uterus by a small orifice *c*; the opposite end *b* is much enlarged, or trumpet-shaped, and is supplied with a dense fringe of the same kind of membrane which lines its interior. The ends last referred to are open; and, though indirectly attached to, they float loosely and slightly apart from the ovaries, except at periods of heat, when their trumpet-shaped and fringed margins

Fig. 4.

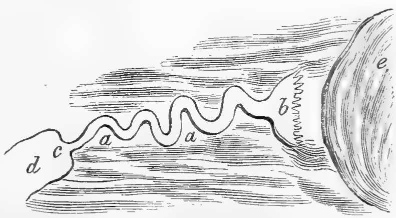


Diagram showing general form and direction of Fallopian tube *a a*, with its expanded trumpet-shaped end *b*, and its narrow or uterine end *c*. *d*, Part of the Uterus. *e*, Portion of Ovary.

are applied to the ovarian surfaces. Their uses are, to transmit the ovum from the ovaries to the uterus, and during its transit to supply it with a covering, which afterwards becomes one of the fœtal membranes.

The uterus—fig. 5, *a* and *b b*—is an elongated hollow organ lying immediately upon the bladder, and below the rectum, or last gut. It occupies in the female a large portion of that interior part of the body called the pelvis. At its front or anterior end it is divided into two parts, called horns, *b b*, one of which is situated on each side, and in pregnancy below, the body of the uterus. Their extreme outward ends give entrance to the fallopian tubes *c c*. In the middle line of the body the horns join together, and form the cavity or body of the organ, which, as a whole, is somewhat pear-shaped, the narrow end looking backwards, and terminating in a tight cartilaginous canal called the opening of the uterus, and technically termed the os uteri, *i*. The uterus is composed outwardly of smooth shining peritoneum; next of a layer of peculiar muscular fibres; and internally of an extension of the same soft, moist, mucous membrane that lines the interior of the fallopian tubes. The uses of the uterus are to contain and protect the fœtus, and to form the medium by which it is immediately nourished.

Fig. 5.

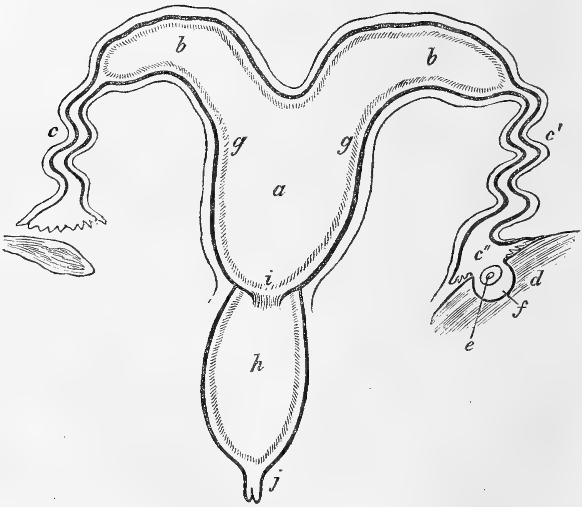


Diagram showing horizontal section of Uterus, Fallopian tubes, &c., at the time of the Ovum passing from the Ovary. *a*, Body or cavity of Uterus. *b b*, Cornua, or horns. *c c' c''*, Fallopian tubes; the tube *c'* is seen attached by its large end *c''* to a portion of the Ovary *d*, and receiving from the rupture therein taking place the Ovum *e*, in order to transmit it to the Uterus after coming in contact with the male seed as it is bursting from the Graafian vesicle *f*. *g g*, The lining membrane of Uterus, forming the *decidua*. *h*, Vagina. *i*, Os Uteri. *j*, Vulva.

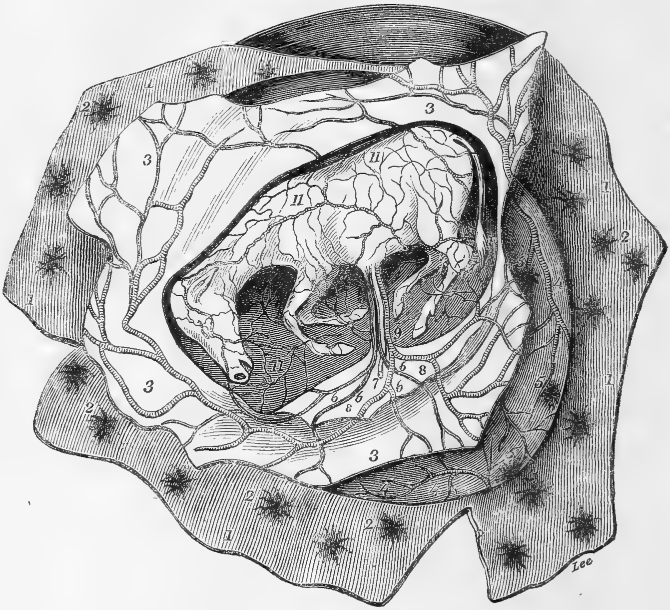
The vagina *h* is a large passage lying behind the uterus, under the rectum, and behind and above the bladder; it is the communication between the uterus, orifice of the bladder, and external organs of generation. In the virgin it exceeds the uterus in size, and, like that organ, is lined by a moist membrane.

By the time that the young female is fit for the propagation of her species, the ova, or cells in the ovaries, have also attained that degree of development which is necessary to ensure fruitful connection with the male. As they ripen they gradually approach the outer surface of the ovary (see *d*, fig. 3, and *e*, fig. 5): this is a periodical process, and takes place during each season of heat, or œstrum, at intervals of three weeks or so in healthy cows in good condition. At this time the broad trumpet-shaped ends of the fallopian tubes *c*, fig. 5, are closely applied over that part of the ovary which contains the ripened ovum. The ovum on reaching this situation causes the wall of the ovary to give way, *e* and *f*, fig. 5, and, passing into the expanded entrance of the fallopian tube, is carried to the uterus. As a result of copulation, the male seed passes from the uterus along the tube, and comes in vivifying contact with the ovum on its escape from the ovary. After this union or contact between the active reproductive principles of the sexes, certain further changes take place, one of which is, that the ovum, in passing along the tube to the uterus, becomes invested externally by a rough covering, which afterwards forms a fœtal membrane, and is subservient to important uses. When the ovum reaches the uterus it is subjected to further and very complicated changes. It loses the simple cellular character, and in a few weeks presents an indistinct or embryonic resemblance to the future animal. During the transit of the ovum along the fallopian tubes the interior of the uterus undergoes changes preparatory for its reception: a membrane called the decidua is formed, and becomes the medium of connection and nutrition between the uterus and its contents.

During the time that development of the fœtus is going on there is a gradual formation, and increase in capacity and strength, of certain membranes by which it is surrounded. The most important of these are termed the amnion, allantois, and chorion. The amnion, fig. 6, 11, 11, 11, lies nearest to the fœtus; it is a soft, remarkably pliable, transparent sac, and contains a great quantity of thick gelatinous fluid, called the liquor amnii, in which the fœtus floats, securely protected, as in a hydrostatic bed. The amnion is prolonged over the vessels of the navel string, 9, fig. 6, and becomes attached to the margins of the opening through which these vessels enter the body of the fœtus. The allantois, 8 8, is a kind of membranous bag situated between the chorion and amnion. Amongst other uses, it serves the purpose

of a temporary urinary bladder for the fœtus. There is a canal called the urachus, 7, leading into it, which passes through the navel opening.

Fig. 6.



FŒTUS AND ITS MEMBRANES, AS CONTAINED IN THE UTERUS.

1, 1, 1, 1, Uterus cut open, and its inner surface and contents shown. 2, 2, 2, 2, Cotyledons, or vascular points giving attachment to corresponding elevations on the Chorion. 3, 3, 3, 3, Chorion cut open, and inner surface shown. 4, 4, 4, 4, Outer surface of Chorion, on which are placed vascular eminences, 5, 5, 5, for connection with Cotyledons of the Uterus. 6, 6, 6, 6, Arteries and Veins passing between Fœtus and Membranes. 7, Urachus. 8, 8, Allantois. 9, Umbilical Cord, or Navel String, formed by blood-vessels and Urachus. 11, 11, 11, Amnion Membrane, containing liquor amnii, through both of which Fœtus is seen.

The chorion, 3, 3, 3, 3, is outside of, and, as its derivation implies, contains the amnion. It is somewhat rough and resisting, and studded with numerous large, elevated, vascular patches or tufts, 6, 6, 6, called cotyledons, which are attached to corresponding points, 2, 2, 2, 2, on the uterus. The chorion is the chief medium of mechanical and nutritive connection between the fœtus and interior of the maternal uterus. The chorion, amnion, and allantois are attached to the navel opening of the fœtus by the umbilical cord or navel-string, which is formed partly by a continuation of these membranes, and in part by blood-vessels. During the later period of gestation the fœtus progressively manifests a resemblance to the future animal; and when it has attained the full development which its uterine connections are fitted to supply, and requires a means of support in common with

the species to which it belongs, it is separated from the maternal uterus by the act of parturition.

When a cow has taken the bull, and conception follows, the œstrum, or heat, soon passes away, and she settles down to manifest no return of sexual appetite during pregnancy. Some striking exceptions to this rule are, however, found, for we have known cows, although in calf, display a desire for the male.

The calves of some of the more primitive breeds of cattle in this and other countries are at birth small in size when compared with some of those borne by our "*improved*" animals. The milk yielded by the native breeds, such as those inhabiting highland districts in this kingdom, is comparatively small in quantity, but rich in quality. These cows generally pass through the periods of gestation and parturition with immunity from many diseases to which higher-bred animals are during such times especially liable, and for the most part bring forth their young without that mechanical assistance which we are in the habit of affording to the short-horned cattle. It has, however, been found that, in order to keep pace with the interests of the age in a commercial, economical, and scientific point of view, the ingenuity of man might be profitably turned to what is called the improvement of breeds of cattle. The objects aimed at in effecting this end are, by judicious admixture of animals, to produce such stock as, combining excellence of external form with milking and feeding properties, shall be most valuable for the requirements of mankind. Any animal that is readily domesticated, and adapts itself to what may be called artificial modes of life, is in the course of years, under the hands of man, made subject to important modifications of external form, accompanied by intrinsic constitutional changes. The cow affords an instructive illustration of this fact; and while we can but confess that some diseases affect our improved cattle which seldom occur among the indigenous breeds, yet we must also admit the great national advantage of that practical application of the science of breeding which has produced our choice animals of the present day.

Symptoms of Abortion.

If abortion take place in the early weeks of pregnancy, it is but rarely that any symptoms are observed which foretel its occurrence. The speedy return of œstrum, however, soon makes the farmer aware that the contents of the uterus have been expelled. It is an interesting fact, and one worthy attention, that the sooner abortion occurs after conception, the sooner also does œstrum succeed the abortion. In some cases the two conditions appear to go together; and we shall often find on observation that the periods of abortion correspond pretty closely with what would be

the periods of recurring heat if the animal were not pregnant. Thus a cow will often abort at the end of the third, sixth, ninth, twelfth week, and so on; but except from accidental causes, she does not so frequently abort in the intermediate periods.

If abortion take place within two or three months of the natural period of gestation, it is denoted by symptoms which, although modified, resemble those indicating ordinary parturition. If it occur before the expiration of the third month, the system of the cow will not suffer much derangement; but if it happen at such an advanced stage of gestation as the sixth or seventh month, it is productive of serious injury, and frequently of great danger to the constitution and even life of the parent.

Before every act of abortion, and at whatever period it occurs, except perhaps before the third or fourth week of gestation, there is a discharge of brown glairy fluid and mucus from the organs of generation. If the embryo about to be expelled be very small, this discharge may be so limited in quantity as entirely to escape ordinary notice, and on that account it is highly important to be acquainted with the appearances which it presents. At first it is brown in colour, and of sufficiently thick consistence to hang in slimy strings from the vulva. Afterwards, in consequence of containing a quantity of blood, and possibly of liquor amnii, it becomes thinner and redder in colour. The discharge is caused by a breach of the natural connections between the fœtal membranes and uterus, in consequence of which the fluid contents of these organs, after escaping into the uterine cavity, are thence expelled. During pregnancy almost all cows have other occasional discharges from the organs of generation, which must be distinguished from that just mentioned, inasmuch as their appearances are perfectly consistent with health. They consist of a thick, *colourless*, *transparent*, and almost *inodorous* secretion, sometimes very copiously supplied by certain parts of the vagina and uterus in the vicinity of the os uteri, and by their consistence and tenacity assist in retaining this organ in a closed condition.

If the cow about to cast calf be in pasture, she may seek to be alone, but on the whole she is not so secluded in her habits as when at the full time of gestation. Cows in the same stock will also smell at her, as though some peculiar odour attracted their notice. If advanced five or six months in gestation, there is a sudden and slight enlargement of the udder; and if she be yielding milk at the time, it will be yellower in colour and greater in quantity than before. The external organs of generation become enlarged and loose in appearance; the ligaments which connect the sacrum (rump-bone) with the bones on each side (ischia) are relaxed, but not nearly to the same extent as before healthy parturition. In young animals pregnant for the first time,

and about to abort, none of the foregoing symptoms (except the discharge) are so plainly seen; in fact they are seldom detected by those in ordinary attendance on cattle. Hemorrhage (or copious flooding of blood), although so frequent and dangerous a precursor of abortion in the human being, is not common in cattle.

The above symptoms may require a few days for their development, or they may be prolonged over a week or more; but if the peculiar discharge continues, and increases in quantity, we may be certain that abortion is at hand. The immediate approach of the event is shown by the animal becoming evidently uneasy, by her shifting from place to place, resting alternately on one hind foot and then the other, twisting the tail, lying down and speedily rising, arching the back and straining, quickened breathing, and accelerated circulation. The symptoms and process of abortion generally occupy less time and attract less notice than those accompanying healthy parturition.

When abortion is caused by mechanical injuries, such as blows, strains in leaping, concussion in running, and so forth, the fœtus is sometimes suddenly passed into the neck of the uterus and vagina, and retained there several days. During this period, especially the early part of it, the cow is continually straining, and suffers a great amount of irritative fever. In some instances part of the fœtus, as its head, neck, or legs, will protrude from the vulva throughout the whole time, and become so firmly impacted in the outer passages as to withstand any reasonable amount of mere pulling force employed to extract it. In these cases the life of the fœtus has in all probability been suddenly destroyed, and the uterus has contracted to expel what has become a comparatively foreign body, before the external passages have been sufficiently dilated to allow its free expulsion.

If abortion take place during the early weeks of gestation, the fœtal membranes (commonly called cleansings), not having formed a firm connection with the uterus, are usually expelled along with the fœtus. In the majority of cases occurring at more advanced periods the cleansing is not expelled; this is partly owing to its firm attachment to the uterus, and partly to its own want of development and deficiency of healthy tone in the uterus to effect its evacuation. This retention is often productive of much distress and injury to the cow, and as decomposition commences in the membranes on their separation from the fœtus, they are the continued source of a most offensive odour and discharge.

There are cases in which all these premonitory symptoms are seen, but, instead of being followed by abortion, there is a gradual arrest of the discharge, the belly of the cow slowly and almost

imperceptibly diminishes in size, the quantity of milk is not lessened, the general health of the animal continues good, and after a time she even shows a disposition to fatten; it will also be observed that she is never in heat, and that the external organs of generation become small and firm. Here, death of the fœtus has taken place, but its expulsion has been prevented, most likely by want of sufficient dilation of the uterine neck, or by a deficiency of tone in the uterus itself. We have known instances of this kind, in which the fœtus has been retained fifteen and eighteen months after the parent had connection with the male, and was only detected in the uterus when the cow was slaughtered, after being fattened. The fœtus under these circumstances is so much altered in external appearance, as to present little resemblance to its natural form, and its internal structures become converted into a dry brownish mass, commonly possessing but little smell. These changes appear to be natural provisions made to effect such an alteration in the dead fœtus as will allow its retention in the uterus with the least inconvenience and injury to the constitution of the parent. In some other instances, when the premonitory symptoms of abortion are not followed by expulsion, there will be a recurrence of temporary fits of straining for weeks and even months, accompanied by a continued discharge of varying colour and consistence; this occasionally contains fœtal bones or portions of them; the larger and heavier bones are retained for a considerable period, being sometimes found in the uterus on slaughtering the cow after she has been fed.

Causes of Abortion.

The causes of abortion are various; but, from extended observation and inquiry into their operation, and in order to generalize their consideration, we propose to consider them under three heads:—

I. *Causes which act directly upon the fœtus, its membranes, or the uterus itself.*
II. *Causes of a constitutional character.*
III. *Causes which, influencing the system or a part of it, operate through it upon the uterus.*

I. *Causes which act directly upon the fœtus, its membranes, or the uterus itself.*—These may also for the most part be considered mechanical causes, consisting, as they chiefly do, in injuries inflicted on the fœtus or the organs containing it. A cow, for instance, which has been severely gored by another cow, or if she has been running or leaping violently, or subjected to any other severe exertion to which she is unaccustomed, is very liable to cast

calf, and the more so if she be some months advanced in gestation. A cow which has had *hoove,* or distension of the paunch by gas, very frequently slips her calf. The effects of the injury in these cases consist in a forcible displacement of the uterine contents, possibly with separation of the fœtal membranes from their connections, to such an extent as to derange the nutritive processes and cause the death of the fœtus. In abortions consequent on blows, the injury is sometimes inflicted so directly on the fœtus as to cause its immediate death; in abortion consequent on hoove, the distended stomach has so forcibly compressed the uterus and its contents by driving them into the pelvic cavity or other constrained position, as to bring about the same result. These mechanical causes are mostly accidental or the result of carelessness on the part of those having charge of cattle, and, on the whole, the number of cows affected by them is comparatively small; hence there are some grounds for the prevalent opinion that, *if merely one or two or a very few cows in a stock cast their calves, the cause is one of an accidental and mechanical character.* In the human female ulceration of the os uteri is a frequent cause of abortion. So far as we know, however, regarding the cow, this has not as yet been satisfactorily shown to be a common cause, although it is quite possible that, from the difficulty attendant on making an examination in the part affected, disease may exist here much more frequently than is supposed.

II. *Causes of a constitutional character.*—In some years there is a singular inaptitude in cows to conceive, although they regularly take the bull at every recurring period of heat during the season. If these do not depend on sexual impotency of the bull, they must be considered as cases of abortion. In the event of their being dependent on sexual inefficiency in the male, it will be found that all or nearly all the cows having connection with him fail to conceive, and other cows in the same neighbourhood, and probably in the same stock, who have taken another bull, are not affected in the same manner. If, from among a number of cows having access to the same bull, a fair amount of conception takes place, and abortion (or want of conception) is seen in others, as shown by œstrum returning at the expiration of the three weeks subsequent to connection, it is fair to infer that the fault does not lie with the male. It is a singular fact that some few bulls, in cows which conceive by them, beget twins, and in other cows fail to produce any offspring. Some bulls will be very prolific one season, and seem almost destitute of procreating power the next, although to all appearance the sexual appetite is as energetic as formerly. Some males are not good stock-getters, in consequence of the too great number of cows they are required to serve. The above facts show that the male seed or *semen* varies in its con-

ditions in the same animal, as well as it does in different animals, and that all cases of apparent early abortion do not depend on sexual deficiency in the female. In cases, however, where it is known that the males are in themselves prolific, the œstrum will still continue to recur in females having connection with them. This is frequently seen in hot and very dry summer weather, and appears in some way connected with it. It must be remembered that at the period of œstrum there is an increased quantity of blood determined to the ovaries, uterus, and, as is visibly seen, to the vagina; and by the animal in heat rambling about, or probably rearing on other cows, the excitability of these parts is so additionally increased as to exercise on the male seed an influence unfavourable to conception. The male, too, in many instances in very hot weather, for various reasons, is sexually less competent than at some other times. The female sexual appetite is most perfect and most regular in its periods of return during the months of spring and earlier part of summer; these seasons seem to favour its development, and it frequently happens that cows which calve in autumn or winter do not take bull until the following spring.

What is called "high breeding" also seems to induce such a state of constitution in animals, as in course of time to predispose them to abortion. One of the most eminent breeders of shorthorns in Scotland informs Mr. Cuming, a veterinary surgeon residing in his vicinity, that when he has got a section of his stock brought to a high pitch of perfection as regards feeding or milking properties, the animals are almost sure to cease breeding, either by not taking the bull at all, or by aborting, most commonly by the two conditions combined. He adds also that the best preventive he has found is to work the animals in plough or harrows like oxen. This is a very instructive fact, and seems, so far as it goes, to confirm the opinion that when the *art* of breeding has been pushed to such a successful extent as to produce animals of great perfection, nature seems to set limits to their further propagation. Subjecting animals to labour as above stated may act favourably on the procreative powers by operating as a kind of tax or counterforce on the extremely artificial state of constitution induced by high breeding. It is always easier to breed from inferior animals of all kinds, than from those of a superior class, and their periods of gestation, as well as of parturition, are passed through with less danger to mother and offspring than is the case in those more highly bred. Thus, we not unfrequently see a very perfect cow or a number of cows put to an equally perfect bull, and are disappointed to find that pregnancy does not follow. In such cases, as these certain "*points*" and "*qualities*," as they are termed, already exist in such a state

of perfection in the male and female, that sexual connection fails to ensure any further advance; nature can do no more, and there must be limits somewhere. In relation with the system of high breeding we must remember that various collateral circumstances are to be considered, which materially influence the constitution of the male and pregnant female. These animals, for instance, are mostly highly fed from birth, are carefully and warmly housed, and have every attention bestowed which can favour their rapid and perfect maturity; they are descended from ancestry which for generations has been equally well attended to, and which was all excellent stock in its day; in fact, they have, as it were, been gradually approaching limits beyond which art cannot further command the resources of nature. If, however, cows such as just named are put to an inferior or comparatively "*ill-bred*" bull, they will for the most part conceive, and the perfect male animal will beget stock in cows much his inferior in "*blood.*" Wild animals very rarely abort or fail to conceive; not having been subjected to the modifying influences which artificial interference entails, they maintain a uniform standard consistent with those capabilities of propagation which have never been forced beyond the natural or original conditions of their constitution.

A cow (and especially a young one) which has cast her calf once, is very likely to do the same again, and usually at about the same period of gestation. To such an extent does this liability exist, that some animals abort for many times successively, and even without any apparent cause beyond that which, to a common observer, appears to depend on *habit*. In the human female this periodical or repeated abortion is also very usual, and most difficult to overcome. It seems owing to a peculiar disposition in the uterus to evacuate its contents, when, in consequence of their development, they have produced an amount of distension beyond which the organ containing them has been unaccustomed to extend. Thus it is that cows having carried several calves to the full period of gestation, although afterwards subjected to abortion, are less liable to become habituated thereto than are young animals which cast their first calves. In the latter case the uterus never has expanded to its full capability, and at a second pregnancy is disposed to empty itself at about the same period, and under the same amount of stimulus as it did before.

III. *Causes which, influencing the system or a part of it, act through it on the uterus.*—In many parts of the country a belief exists that abortion is *contagious*. From extensive observation and inquiry, we find this opinion founded on the fact, that when abortion once commences in a herd of cows, it frequently affects them in considerable numbers. Whilst we must remember that

this is not invariably the case, we are at the same time bound to confess that unless abortion be clearly dependent upon some temporary and accidental cause, it very frequently befalls a number of cows in the same stock the same season. In this, however, there is nothing to establish its contagious character, for many diseases well known to be destitute of contagious properties will occasionally prevail very extensively among various kinds of animals. Much more than the simple extensive prevalence of a disease is required to prove its contagious nature: we must show,

a. That animals subjected to its supposed influence are affected in greater numbers than others; thus, on introducing an animal or animals affected with a disease among healthy ones, the latter to a greater or less extent within a certain time are affected by the same disease.

b. That the separation of diseased from non-diseased animals has a perceptible effect in arresting extension of the malady.

c. That those animals earliest and most closely connected with the sick are first affected.

d. That large numbers of animals remain unaffected so long as they do not mix with those which are diseased, although they live in the same building or neighbourhood inhabited by those among whom the disease existed.

Now, admitting that abortion in its ordinary occurrence is a disease, and although, as has been stated, it may be induced by causes of various kinds (some of which have been named), yet, having once occurred among a stock of cows, its further extension among them does at first view seem conformable to the conditions here laid down as proving the character of diseases to be contagious. For cases can be adduced to show that when one or two cows in a herd have, from whatever cause, cast their calves, others pregnant will do the same; and that on a careful and early separation of those first aborting from others still pregnant, the latter remain unaffected.

There are, however, other considerations to be entertained here. In contagion we assume that matter in some tangible form, or minutely and invisibly diffused in a gaseous condition, emanating from a diseased animal, passes to some absorbing surface in the body of a healthy one, and there becoming further developed, produces disease also. We think the strongest advocate of contagion in the present instance is not prepared to assert that the discharge incident to abortion can be transmitted from the body of one cow to another in the ordinary course of things; and even if such transmission could be effected, we can hardly imagine how abortion could be induced thereby. It is, however, said that the odour attendant upon these discharges, on being

smelled by pregnant cows, causes them to abort. But surely this smell cannot act directly upon the uterus, for this organ in itself possesses no power of detecting varieties of odour. We do know, however, that cows are especially acute in detecting, by the sense of smell, when one of their companions has calved, either prematurely or at the full time of gestation. If a birth take place in the pasture, the cows will collect round the locality at the time, and for many days even weeks subsequently will visit and smell at it with a degree of apparent curiosity and pleasure. If a cow calve in the house, other cows are at once aware of the fact, as is shown by their looking about them, snuffing their noses, and by making the fondling noise usually uttered towards their young. It is also interesting to notice that if a cow at or near her full time of gestation calve among a number of her pregnant companions, several of them will usually bring forth their young very soon afterwards, although appearances and record might have led us to suppose that their times of parturition would have been deferred, instead of so closely corresponding. Seeing then that cows are aware of the parturition of their companions, how do they become so? From noticing them at the time, and for various other reasons, we believe that the organ of smell is the channel or medium through which the impression or sense is communicated.

It remains, then, to inquire whether the sensation produced by a peculiar smell or odour can, by "*influencing the system, or a part of it, act through it* upon the uterus," so as to cause abortion. Preparatory to this short inquiry (and as illustrating the kind of action to which we would refer) we may observe, that in the animal body we often find a cause of disease acts through one part of the system upon another. For instance, a person with an irritably constituted stomach is seized with nausea or vomiting on smelling a peculiar odour or on seeing some disgusting object; here the eye becomes first cognizant of a cause which operates subsequently on the stomach. A person with irritable bowels becomes affected with purging on "taking cold," or from having wet feet; here cold as a cause acts first on the external surface, and operates subsequently on the bowels. Almost every animal has some part of the body more susceptible than the rest, and especially liable on that account to become affected by the causes of disease. On this depends the differences of constitution seen in the human being and also in the lower animals. At the same time, we must remember that the various organs of the body when in a state of health act in obedience to certain stimuli; air is the stimulus to part of the respiratory action, and food is the stimulus to the digestive organs. If such stimuli are unnatural in amount or quality, they induce disease; impure air

causes affections of the lungs, and food undue in amount or bad in quality produces disease of the stomach and bowels.

The uterus and ovaries of the young virgin female of any animal are organs of comparatively small size, and not being concerned in the performance of functions essentially necessary to the vitality of the body, they receive but a small supply of blood and nervous influence. At the adult period of life these organs, having attained their full development, exercise upon the system an influence of the most important kind. In the cow at periods of œstrum they receive a greater amount of blood, and their nervous susceptibility is greater than heretofore. If she be allowed intercourse with the male, conception follows; the presence of the fœtus maintains a stimulus in the uterus which is continued till the time of parturition; the quantity of blood determined to it is enormous, and the peculiar kind of nervous influence required to take cognizance of its functions progressively increases as gestation advances. The gravid uterus then is the seat of a healthy excitement, and the due preservation of this depends partly on a comparatively quiescent state of the rest of the system; hence the cow during pregnancy is more than usually docile. Some persons are of opinion that the imagination of a pregnant animal is easily acted on by impressions which at other times would scarcely produce any effect, and many cases can be adduced which show that sudden fright and intense mental emotion have been followed by abortion.

When a pregnant cow, then, is so situated that she can smell the odour arising from another cow which has aborted, we may reasonably expect that the sensation so produced will, from what has been stated, be attended with peculiar consequences. The circle of nervous influence, which establishes a connection between the organs of smell, the brain, and the uterus, will be influenced thereby, and the *uterus*, from the predisposing nature of its condition and functions, especially responds to this peculiar stimulus. Irritation applied to nerves induces action in organs to which such nerves pass, and, in the present instance, *action*, as a result of nervous excitement, is induced in the uterus, which organ continues from time to time to act upon its contents until they are expelled. Thus we conceive it is that odours arising from cows casting calf induce abortion in others of their pregnant companions, and by adopting this explanation we can account for the *apparently* contagious nature of abortion, without admitting that it is contagious in reality. Other odours of an offensive kind are believed by some (and we think, with good reason) to cause abortion. Cattle will often collect in numbers around places containing decomposing animal and vegetable matter, and by bellowing, and tearing the earth with their feet and horns,

will betray a high degree of excitement; this, especially to pregnant animals, cannot fail to be injurious.

Over-feeding seems sometimes to cause abortion, by promoting such a state of system in the cow as is unfavourable to a healthy development of the fœtus. It is not animals in a plethoric habit of body that are best adapted for breeding; indeed it is a common remark that fat cows have generally smaller calves than those not in such high condition. Large quantities of rich and stimulating food may favour the deposition of fat in a pregnant cow, but her circulating blood, by being highly charged with nutritious material, becomes less adapted for the requirements of fœtal subsistence. In some parts of the country where cattle are fed on low marshy ground, or on land yielding rank and succulent herbage, such as grows on meadows occasionally flooded, abortion will occasionally occur to a great extent. It seems here to be induced by the irritating or stimulating action which the herbage of these localities exercises on the bowels, which action, being of prolonged duration, ultimately influences the uterus. There is great sympathy (so called) between the uterus and digestive organs; they lie in close connection with each other, are formed of the same kind of muscle and membranes, and are supplied with blood-vessels and nerves from the same common centres. Among organs in the animal frame so related, there is always a strong disposition to become affected, each in its own way, by much the same common causes of disease, provided those causes act with sufficient intensity. An opinion obtains in some localities that abortion is produced by cattle drinking the water of particular streams and springs which contain an undue amount of mineral material. Some waters are known not to agree with animals, more especially with man and the horse, and it is quite possible they may exercise an injurious effect on cows also, but whether any waters which cattle will usually drink are really capable of producing abortion, observation and fair experiment have not yet, in our opinion, sufficed to prove. It is very rare indeed that cattle, if left to themselves, will eat any kind of plants which produce injurious effects on the system; their exquisite sense of smell and instinctive knowledge cause them to avoid deleterious vegetables as food. We know of no cases in which abortion was fairly traceable to the action of acrid or poisonous plants.

Treatment of Abortion.

This is to be considered under two heads; first, the *preventive*, and, second, the *remedial treatment*: the former is to be enforced when certain symptoms present themselves, which, as has been before shown, threaten abortion, and is also to be applied to pre-

vent extension of abortion among healthy animals. The remedial treatment is to be employed in cases of actual abortion.

1. *Preventive Treatment.*—If there are grounds for believing that abortion is caused by mechanical injury, the owner of cattle must exercise strict vigilance over those to whom he intrusts the management of his stock. He must provide against them being apt to suffer from leaping, as they are liable to do when mischief or other inducements tempt them to break their fences. If a pregnant cow has "hoove," the veterinary surgeon or person in attendance must adopt the most summary way of liberating or neutralizing the gas. Every cow should be separated from her companions immediately after she has cast calf, and placed in such a situation that all communication with them by means of smell or otherwise may be prevented. She must be well supplied with bedding, which is to be kept clean by frequent changing. Care must be taken that the discharges do not collect about her, and if the placenta is retained, means must be used to neutralize the odour arising in consequence of its decomposition. The animal must be kept in a cool, pure atmosphere, and supplied with food and water in moderate quantity. It will be observed that many of the above precautions, which are here advised as means of preventing extension of smell subsequent to abortion, are also highly useful as means of remedial treatment.

Strict attention must be paid to the cows among which the affected animal was kept, in order that the premonitory symptoms of abortion may at once be noticed if they occur. The peculiar coloured discharge, which has been before alluded to, is always to be taken as an indication of danger, and if, in addition to its appearance, there is a visible sudden increase in size of the outer organs of generation and udder, beyond what the period of gestation would warrant, we have little reason to doubt that abortion will take place if means of prevention are not employed. The animal must be copiously bled, placed in a situation where she can be kept perfectly quiet, her diet must be moderate and of such a quality as will favour an open condition of the bowels. *No purgative medicine must be given*;—the irritation which this creates would increase the abortive tendency. Our object here is to tranquillize the system and the uterine excitement, and to attain this end we may advantageously administer sedative medicine. None is better than such a formula as the following: 2 oz. of tincture of opium, and 2 oz. of nitrous æther, mixed in an imperial quart of gruel, and given daily, or so long as circumstances seem to require it. Cold water may be copiously applied to the external parts of generation several times daily. We often find that if the above simple means are timely and energetically employed the symptoms of abortion entirely disappear.

If the liquor amnii has been partially evacuated, and the animal, by arching her back and tail, by lying down and suddenly rising again (as well as by exhibiting other usual symptoms), seems actually in labour, the treatment just advised would not only be useless, but highly injurious also. Matters in this case must take their course, for it is only in the absence of the symptoms of immediate labour that bloodletting and the other means recommended can be employed.

If abortion take place at an early stage of gestation the premonitory symptoms are rarely noticed, the fœtus with its membranes will be expelled without occasioning much inconvenience to the cow, and œstrum will occur a few days afterwards. The animal, however, should not be allowed access to the male, for her organs of generation are in a state of morbid excitement, and connection with the bull under such circumstances is seldom followed by conception. The cow should be tied in the house until the œstrum has disappeared, and should be carefully watched for its next recurrence, which if taking place at the natural period, she may be put to the bull and kept perfectly quiet a few days longer. If a cow has irregular periods of œstrum, such as at every ten days or a fortnight, she is almost always the subject of some ovarian or uterine disease, and on no account should such an animal be allowed to have connection with the male, or to be in company with pregnant cows, or cows which are taking the bull in ordinary regularity. Such beasts mostly go bellowing about the pasture for days together, they gradually grow thick and coarse in the head and neck, and their outer organs of generation lose much of the natural appearance; they are hurtful nuisances, and should be fed if they will feed, or disposed of in some other way, being utterly worthless for breeding purposes.

When the œstrum returns in a cow regularly every three weeks, and she takes the bull each period without conception following, and we have reason to believe that no sexual deficiency exists in the male, she may frequently be put under treatment which will ensure pregnancy. She should not be allowed connection with the male until the latter part of the period of heat, and after taking the bull she should be bled freely, and confined several days after œstrum has disappeared. During the time of being kept up, a moderate amount of her usual food must be allowed; no medicine of any kind is needed, but, if the owner please, he may from time to time throw a pailful of cold water on the hinder parts of the animal, especially over the organs of generation. No cow after taking the bull, and while still in heat, should be allowed in pasture with other pregnant cows; her society unsettles them, and by smelling at her they receive impressions which act injuriously. When an indisposition to conceive, or, as it is some-

times termed, "*breaking bull*," exists extensively in a stock, and the cows in numbers are continually coming in heat, they should all of them be confined in the house till œstrum is about going off, then be put to the male, and confined for a day or two more. If the farmer thinks proper he may bleed them; this, beyond lessening their milk for a few days, will do no harm. The medicines which farriers and old women sometimes recommend to make cows "hold to the bull," or conceive, are unworthy of dependence.

A cow which has cast calf several times in succession acquires such a habit (if it may be so termed) of doing so, that it is exceedingly difficult to overcome. Notice should be taken of the period of each abortion, and in her next pregnancy, a fortnight or so before the accession of this period, she should be bled, tied up, and treated as before advised for prevention. She should be confined for some time, so as to ensure the utmost quietness. If such measures are not effectual towards promoting what is desired, it is best to feed or sell the animal. Such cows as this, on being taken to another farm or fresh herd, will very often take the bull and carry their calves to the full period of gestation.

In those unhappy instances where abortion to a destructive extent occurs in a stock of cows for years successively, and seems rather to increase than to diminish in prevalence, we have to contend with the pest in its most formidable character. A breeder or farmer does not like to sell animals to which he attaches great value, yet by separating the affected from the non-affected cows, and by adopting every other remedial and preventive plan of treatment which his own experience or professional knowledge can suggest, he sees matters becoming worse season after season. We believe that under the circumstances nothing short of thoroughly changing his affected stock, by feeding or selling them off, will be of any service. He may do so at a great sacrifice, but it will be less than the one which from appearances he will in all probability incur, by having every year a number of cows supplying neither calves nor much amount of milk. The longer this decisive step is delayed after fairly trying other methods of prevention, the worse matters usually become; and hence the importance during two or three years, when abortions are few in number and confined to much the same cows, of feeding or otherwise disposing of these animals.

If abortion be confined mainly to animals in high condition, it is generally fair to infer that over-feeding is the predisposing cause, and the other cows still pregnant may, at all events, be more limited in diet. If, on the other hand, it seems to depend on poverty in condition, a more liberal supply of food is the obvious remedy. When it is owing to the irritation or exhaustion

caused by other diseases, such as consumption, dysentery, murrain, &c., there is little probability of any preventive measures being attended with success, even if it were worth while to employ them.

2. *Remedial Treatment.*—It has been stated, that when abortion occurs during the first few weeks of gestation, it does not seem to occasion much inconvenience or constitutional disturbance to the cow. At this period, as the fœtus is of small size, the membranes are also in a rudimentary state of development, and are not so firmly attached to the uterus as they ultimately become; on this account they are readily expelled with their contents. Little treatment is required in cases of this kind, beyond keeping the affected cow from her companions, and also from the male.

Abortion occurring subsequently to the ninth or twelfth week is a more serious matter. Here the premonitory symptoms may also have escaped notice, and the fœtus may have been expelled without any difficulty, but the placenta is almost always retained, and becomes an offensive source of annoyance to the cow and her attendants. There is sometimes very little of it hanging from the vulva, and a slow decomposition, attended by discharge of a peculiar and most offensive odour, is established in the protruding portion, as well as in that retained in the uterus. Decomposition is commenced in some cases before abortion takes place, and little or none of the cleansing will make its appearance for some days after expulsion of the fœtus. The presence of this now foreign body in the uterus and vagina induces an unhealthy inflammatory condition of the lining membrane of these organs, and, from the irritation thus established, it is not unusual for the cow to become feverish, refuse her food, and rapidly fall off in condition.

The fœtus is to be securely buried as soon after abortion as possible. All persons agree in the propriety of adopting such a practice, but a singular difference of opinion exists with regard to the propriety of removing the cleansing, or of suffering it to remain. Those who advocate letting it remain, advise that the passages containing it should be kept as clean as possible, and that antiseptic preparations should be used to destroy the offensive odour which it generates. They seem to imagine that danger which they cannot describe is likely to arise if mechanical means are employed to remove it. A person, however, who understands the anatomy and functions of the organs concerned is fully aware that such an idea is fallacious, and knows that, unless under some peculiar circumstances, he can take the cleansing away with perfect safety. It is surely better to do this than subject the cow to the well-known inconveniences of its retention. In order to satisfy himself of the propriety of removing it, the operator, after

having the cow securely held, washes out the vagina with warm water; he then introduces his hand well oiled, to feel if the os uteri is sufficiently open to allow it to pass into the uterus; if so, there is not the slightest danger in attempting to take the cleansing away. Should any part of the membranes be hanging from the vulva, they must be taken hold of by the other hand, twisted several times round (so as to render them less liable to break), and pulled at gently. By thus stretching them the operator is better enabled to feel with his hand in the uterus where the attachments between it and the cleansing are situated. He gradually passes his hand round the interior of the uterus and loosens the points of connection, commencing at the entrance and proceeding to the horns of the womb, to one of which the cleansing is mainly attached. He may require to exercise some degree of pulling or separating force with the hand thus employed, and should be careful not to tear the cleansing more than he can possibly avoid; it is always better to remove it at once (if possible) than piecemeal. When the hand can be passed into the uterus, and if decay of the cleansing be not too far advanced, there are very few cases in which we cannot remove it by exercising due precaution. After extraction has been accomplished, the uterus should be gently but well syringed with tepid water, among which a small quantity of chloride of lime may be dissolved. A competent operator incurs no risk of injuring the uterus, for all the necessary force of manipulation is applied to the attached points of the cleansing.

Some persons who have objections to the above mode of proceeding, in consequence of the extremely offensive stench, the disgusting nature of the discharge, or from an erroneous idea of injurious consequences which they suppose likely to ensue, attach weights to the cleansing, in order, as they imagine, to drag it away. The force thus applied mostly causes the membranes to break inside the vagina, and not being determined to the real points of attachment, is seldom of much benefit; moderate pulling force occasionally applied by the hand in a horizontal direction is much preferable, although but rarely effective in bringing the cleansing away. If the prejudice of the owner be such as not to allow of any mechanical interference for its removal, and if he be not incorrigibly careless and ignorant, he may wash the cleansing repeatedly with a solution of chloride of lime, and inject a diluted form of the same into the vagina; this, with a plentiful supply of clean litter, will in some measure overcome the effluvia always present in these cases. Some farmers smear the walls and woodwork of their cowhouses with tar and melted pitch, to counteract, or, as they think, to prevent the smell alluded to; there is no harm in adopting such a practice, but there is little amount of

good derived from it in comparison with that attendant upon taking the cleansing away, rigidly separating the affected animals from others, and otherwise treating them as here advised.

"Cleansing drinks," so called, are extensively prescribed by farriers and druggists in various parts of the country, under the idea that such compounds in some way or other promote expulsion of the cleansing. These drinks are for the most part composed of stimulating aromatic ingredients, combined with purgative and diuretic medicines. They are seldom productive of any good effects beyond those which depend on their purgative action, whilst their aromatic and resinous properties very frequently render them highly injurious, by acting directly on a class of organs previously irritated, and probably in a state of inflammation. A dose of saline purgative medicine, such as half a pound to a pound of Epsom salts, with an ounce of ginger, and half a pound of treacle, mixed in a quart or three pints of meal gruel, is frequently of service, and forms about the only "cleansing drink" which the non-professional man should trust himself to administer. If the animal be really weak and in low condition, half a pint to a pint of good ale may be combined with the drench here recommended. If the bowels are already sufficiently open to forbid the use of laxative medicine, ale with treacle-gruel may be given instead. Ergot of rye is much relied on by some, as causing expulsion of the cleansing. We have not found it to be a medicine to be depended on in this respect. It has been given in two-drachm and half-ounce dozes to pregnant rabbits and bitches daily, for weeks together, without producing any perceptible uterine action.—(See "Edin. Med. and Surg. Journal," for 1840.)

If the placenta is retained, and the hand of the operator cannot be introduced into the uterus in consequence of contraction of the os uteri, and if no part of the cleansing can be taken hold of, the calf-bed must be syringed with warm water by means of a suitable instrument, which the veterinary surgeon for the most part is alone competent to use. It is improper to attempt removal of the cleansing, as before advised, if the hand cannot be introduced into the uterus by applying a moderate degree of dilating pressure, or if the cleansing is so firmly attached as not to give way to the application of reasonable force.

After some cases of abortion, as well as after some of ordinary parturition, the cow is affected with severe straining, or bearing down, called after-pains. These will, in cases of abortion, sometimes continue for several days, and induce a highly feverish state of system in the suffering animal. They are occasionally accompanied by a discharge of blood, and are mostly observed when the cleansing is entirely retained in the uterus,

and apparently depend on the already irritable calf-bed suffering under additional excitement induced by the dead weight and peculiar position of the cleansing, now to be regarded as a foreign body, and which it is desirable to expel. After ordinary parturition these straining efforts are sometimes so energetic as to cause "throwing down" of the uterus. Although this accident seldom occurs after abortion, in consequence of the small size of the os uteri and outer passages, yet, for the relief of the animal, it is desirable that, if possible, these pains should be overcome. Two or three ounces of tincture of opium and two ounces of nitrous æther may occasionally be given in a quart of warm gruel. The hand should be introduced to ascertain if the cleansing be loosened and, as is sometimes the case, entangled upon itself near the neck of the uterus; if it can be removed, or even drawn towards the vagina, straining mostly ceases.

A cow after abortion should be fed on good food, but of such a quality as will induce a lax condition of the bowels; boiled barley or linseed, cooked roots, as turnips and carrots, form excellent diet. If from prolonged straining and other causes of irritation she is so feverish as not to feed at all, she must be offered plenty of drink, and if she will take flour or linseed gruel sweetened with treacle, we need be under no great anxiety regarding her not feeding. Provided she will neither eat nor drink, we must (during the time our best endeavours are directed to the removal of the real cause of irritation and fever) support her by administering gruel with a horn or bottle. The stimulating drenches of the farrier and cowleech must be strictly avoided; if any tonics or mild restoratives be really needed, the using of them can only safely be intrusted to the veterinary surgeon.

When abortion is caused by mechanical injuries suddenly inflicted, the uterus sometimes begins to contract, and forces the fœtus into the os uteri and vagina before these organs have been sufficiently dilated to allow its free expulsion. The cow may even continue straining for days, and all her efforts only seem to impact the fœtus still more firmly, and some part of it, as the head, neck, or feet and legs, will for this period protrude from the vulva. In some cases her strength becomes exhausted, and she may die undelivered. This untoward event more particularly occurs to young animals, where the passages to the uterus have not acquired that capacity which they attain during the process of natural parturition. The assistance of an experienced practitioner is required here, and, for the safety of the mother, he frequently finds it needful to dissect away the fœtus piecemeal. In some cases firm and judiciously applied pulling force will be sufficient to effect its abstraction; in others an incision may be made with a suitable knife along the lower part

of the belly and chest of the fœtus, the viscera of these cavities removed, then, by drawing at its head and legs, the sides of the body are compressed, and delivery is effected.

"*Cross births*," or "*false presentations*," seldom interfere with delivery in abortion occurring at an early period of gestation, but if it be delayed till within six or nine weeks of the time of natural parturition, they sometimes prevent expulsion of the fœtus. False presentations with abortion are often more difficult to rectify than when they occur at natural parturition, and in cases of this kind the aid of an experienced and dexterous practitioner is required, whose best care is needed to ensure the cow's safety. If she has been straining for some time, and the liquor amnii is partly evacuated without any appearance of the fœtus, the hand of the operator must be introduced to ascertain its position. The presentation is almost always unnatural if the fœtus is not expelled within a reasonable time after rupture of the membranes, yet in some instances, although the water-bag has burst, the cow is cruelly allowed to pass several days under labour-pains without attempts being made to relieve her. This is culpable neglect, for delay of this kind always increases the danger and difficulty of delivery, and retards recovery. On introducing the hand it is possible that the os uteri may not be sufficiently open to allow the necessary manipulation; such being the case, steady attempts may be made to dilate it, and sufficient time allowed for the purpose. If the pains are very severe an occasional dose of laudanum may be given to relieve them; *chloroform* is highly efficacious in promoting the same end. Some persons advocate bleeding, but this is a remedy which, under all circumstances of the case, we would rarely advise. Other practitioners recommend the application of extract of belladonna and other sedative substances to the os uteri; their beneficial action, however, is very doubtful. We believe that cautious continued attempts at dilatation, by expanding the hand in the contracted part, affording due time for the efforts of nature herself, and the administration of tinct. opii, as advised, are the safest and most efficient means of promoting enlargement of the os uteri. When the opening is sufficiently increased in size, the presentation, if false, must be rectified, and the fœtus taken away. The methods of remedying these presentations must be left to the practitioner, and are chiefly the same as those required in like cases attendant on ordinary parturition. When delivery is completed the cleansing must be taken away by adopting the method before advised for its removal.

After abortion, even in cases where the cleansing has been expelled, a discharge of a peculiar kind usually flows from the uterus for several weeks successively. It is different in character

from the natural *lochia,* and if so copiously secreted as to interfere with the comfort and health of the animal, we may advantageously counteract its ill effects by occasionally syringing the uterus with tepid water and diluted solutions of the chloride of lime. Sulphate of iron in half-ounce doses, finely powdered, and given twice daily among a mash, will be found a very useful tonic; it also seems to possess some effect in arresting the discharge and in restoring the mucous membrane of the uterus to its healthy tone.

Cows, and especially young ones, which have aborted, and have had great difficulty in delivery or in getting rid of the cleansing, are frequently a long time before they will again "take bull." This indisposition for sexual connection with the male, induced by injuries which the uterus has sustained and the shock which the system as a whole has received, is best overcome by giving tonic medicines, using every possible local application to restore natural tone in the uterus, and especially by allowing plenty of good food, air, and exercise. Inflammation of the uterus sometimes succeeds abortion; it is induced most frequently by the rough usage to which the uterus is occasionally subjected, and is known by the animal becoming feverish, being off her feed, breathing quickly and laboriously, arching the back, straining, and voiding considerable quantities of brownish-looking fluid tinged with blood, which, in advanced stages of disease, is mixed with portions of the inner lining of the uterus, emitting a highly offensive odour.

In treating this affection the uterus must be frequently but gently syringed with tepid water; hot sacks or cloths wrung from hot water must be laid on the loins; the bowels must be kept gently open by means of mild laxative medicine if required, and plenty of tepid water or gruel must be given to drink. When a favourable change is about taking place, the uterine discharge becomes lighter in colour, and eventually assumes the character of pus; return of the appetite speedily follows, and a rapid abatement of the fever is also obvious. This disease, when owing to a considerable rent or tear in the uterus, is generally fatal in a day or two.

There are some few cases in which death succeeds abortion in a remarkably short space of time, and seems to come on without any apparent cause. It will, however, generally be found that in instances of this decription the cow has been roughly handled, has been many hours, and may be days, in painful labour, has had little nourishment afforded, and was perhaps constitutionally weak in the outset.

IV.—*Some Observations on the Chemical Composition and Agricultural Value of the Fossil Bones and Pseudo-Coprolites of the Crag.* By Thornton J. Herapath.

It was not many years since that the celebrated Professor Liebig, of Giessen, in one of his works on agricultural chemistry, observed, when writing on the importance of phosphate of lime in the vegetable economy, "In the remains of an extinct animal world, England is to find the means of increasing her wealth in agricultural produce, as she has already found the great support of her manufacturing industry in fossil fuel." At that time, however, little or no attention was paid to the prediction, which was regarded merely as one of the few brilliant but erroneous speculations that have emanated from the master-mind of the same most eminent philosopher; but more recently, guided by science, geologists and agriculturists have succeeded in demonstrating its truth, and have shown that, in many of the formations which constitute (if I may be allowed to use the expression) the groundwork of this island, lie concealed mines of manure almost equal in value to the guano of Africa and Peru, which is now oftentimes collected with so much risk and labour, and eagerly purchased by our farmers at so high a price—a manure, indeed, which only requires to be subjected to certain simple treatment in order to become a rival of that most remarkably fertilising substance in alleviating the wants of the agriculturists. The existence of these fossil remains in our soil was, I believe, first pointed out by Drs. Mantell and Buckland, though it is to Professor Henslow that we are indebted for having called attention to their eminent agricultural value, and described the localities whence they may be most readily obtained.

Phosphoric deposits have been met with in several formations; but would seem to occur in by far the greatest abundance in the more recent tertiary strata, as a layer between the coralline crag and London clay. The layer or stratum in question varies in thickness in different localities, sometimes averaging not more than two inches, whereas at others it often exceeds a foot or 18 inches in thickness. It consists almost entirely of the fractured and rolled bones of cetaceous and other animals, which have been thrown up and deposited there in the convulsion that ended the clay deposit and ushered in the crag or deeper sea formation.

Mixed with these bones are found many fish-teeth and shells of different species, and likewise immense numbers of rolled water-worn pebbles, which, at one period, were imagined to be the fossilized excrements of the animals themselves, and were on this account called *coprolites* by Professor Henslow and others. Recently, however, the fallacy of this view has been proved, and Pro-

fessor Buckland now recognises them by the name of pseudo or false coprolites, as he does not conceive them to be of truly animal origin, but considers them merely as calcareous pebbles which have undergone a peculiar metamorphosis and become impregnated with phosphoric matter by long-continued contact with decaying animal and vegetable substances. Such phosphoric nodules, however, it must be recollected, contain a large proportion of phosphate of lime and other earthy phosphates, as will be presently shown, and consequently are far from being useless for agricultural purposes. In fact, as will be hereafter pointed out, they contain almost as large a proportion of these fertilizing ingredients as the bones with which they are associated, and are actually superior in this respect to the true coprolites which are met with in Dorsetshire and other counties. The bones themselves, as I have before observed, generally occur in a broken or fractured state, and evidently belonged for the most part to those rapacious monsters the sharks and gigantic sea-lizards and whales (Enaliosauri and Ceteosauri), which at one period of our earth's history must have existed in such myriads in our oceans and seas.

Still more recently, it has been discovered, that somewhat similar phosphoric deposits occur in the lower strata of the cretaceous system ; that is to say, in the upper and lower green-sand formations which lie below the chalk ; and in an excellent paper which appeared in a recent Number of the Journal of the Royal Agricultural Society,* Messrs. Paine and Way have directed attention to them, pointing out their geological position and the manner in which they may be most economically collected and applied to the purposes of the agriculturist. It is not my intention, however, in this communication, to treat of the fossils of the green-sand—this subject having been already so fully discussed by the above-mentioned gentlemen, leaves nothing to be desired. In the present memoir, therefore, I purpose to confine myself almost entirely to the details of my analyses of the fossil bones and pseudo-coprolites of the crag—to the consideration of those remains which are met with in such enormous quantities on the coasts of Suffolk, Norfolk, and Essex, where several hundreds of persons are now actively employed in exhuming and collecting them, with the view to their future conversion into artificial manures. It is from these counties, indeed, that Mr. Lawes, of Rothamstead, obtains nearly the whole of the material he employs in the preparation of his well known "coprolite manure;" and so extensive is the demand for this description of fertilizers for wheat and turnip-growing lands, I am credibly informed, that several thousands of tons of fossil bones, &c., are annually sold in

* Vol. IX. Part I. p. 56.

this country under one form or another, and the consumption of them is daily and rapidly increasing.

The strata where these remains are found in greatest abundance and are most economically attainable (as I believe I have before had occasion to observe), are the loose green-sands and supercretaceous ferruginous sandy crag of Suffolk, &c. The green-sand of Hastings, where they have been lately found, is very superficial, as is also the crag. Both are easily worked through, and there the fossils are found rolled together in large thick masses. In the more consolidated strata, the working of course is more expensive, the remains are more scattered, and the separation of the valuable from the useless portions is thus rendered almost impossible. The Suffolk crag being exceedingly rich in fossils, both as regards number and quality, and the expense of water-carriage to any part of the eastern coast-line being at the same time very trifling, this county necessarily offers peculiar advantages to those who are engaged in this branch of traffic. The contract which is usually entered into in this county for the labour of raising these remains, namely, for digging, screening, washing, and storing, amounts to from 4*s*. 6*d*. to 5*s*. per ton; whereas, delivered on board the vessel, the charge to the purchaser is 30*s*. to 45*s*. per ton. This difference in price, it must be understood, has no respect whatever to the *chemical* value of the fossils, but is to be attributed solely to the cleverness, or rather cupidity of the seller. Taking the lowest price, however, it will be seen that a clear profit of 20*s*. or 25*s*. per ton is gained by the owner of the land. So large, indeed, is the profit thus obtained, I have been told, that the produce of a few acres in fossil bones, &c., when sold, has been often known to realise the full value of a small estate; whilst at the same time it must be recollected, that the land itself is actually improved by the course of treatment to which it is subjected, when excavating for the fossils. 60*l*. to 70*l*., and even 80*l*., have been repeatedly given for liberty to dig over a two-acre field.

In many parts of the Suffolk coast, the manure is prepared directly upon the spot; that is to say, the coprolites and bones are reduced to a coarse powder in mills of a peculiar construction and great power, furnished with vertical granite and buhr stones; they are afterwards mixed with about an equal weight of strong sulphuric acid or oil of vitriol, in tubs, &c., and are thus converted into superphosphate of lime; whilst in other cases they are transported by water to other places, where large manufactories have been erected for the preparation of artificial manures.

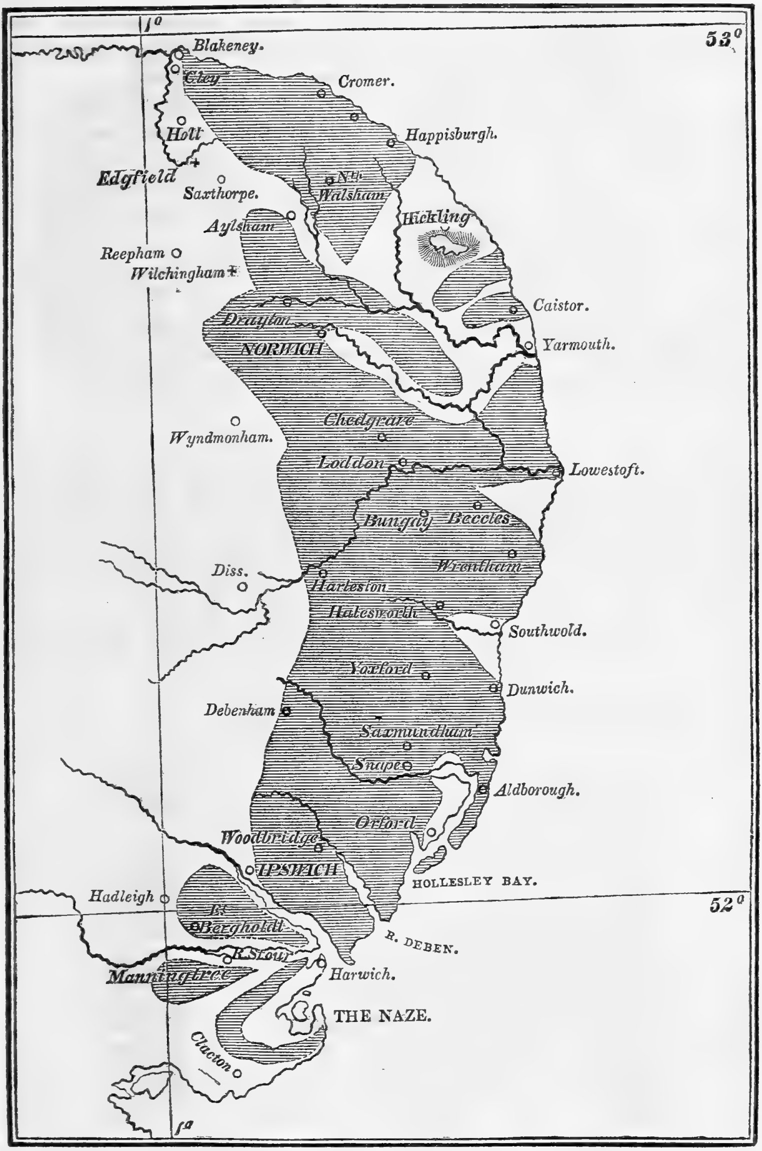
A mere inspection of a geological map of England would suffice to point out those places where the remains will most probably be found; but in order to spare the reader the incon-

venience of reference, I have annexed a small map, which shows the position of the crag along the coasts of the counties I have named. By glancing at this, it will be seen, that the crag formation is extended over a district of country about 65 or 70 miles in length by 10 miles in breadth. Only a very small portion of this district, however, has as yet been examined; the greater number of fossil quarries or mines (if they may be so called) having been opened in the neighbourhood of Ipswich, Brampton, Sutton, Saxmundham, and Buxton. But this condition of things will not exist much longer; the eyes of the proprietor of the soil will soon be opened to the sources of wealth which lie beneath its surface, and in a short time—a very short time perhaps—these fossil remains will be sought after as eagerly as the seams of coal with which Liebig has so happily contrasted them.

With regard to the process of analysis which was employed in these examinations, it differed but slightly from that ordinarily adopted. The only novelty consisted in the method of estimating the fluoride of calcium. The quantitative estimation of fluorine, it is well known to chemists, is accompanied by no slight difficulty, particularly when that substance is associated with phosphoric and carbonic acid. The manner in which I proceeded to effect it in the present analyses was as follows:—

The finely powdered bones or coprolites, having been heated to redness, were dissolved in dilute hydrochloric acid, and the solution was then evaporated to dryness. The dried mass thus obtained was reduced to a fine powder, and heated to from 350° to 400° F. in a sand-bath, in order to expel all traces of hydrochloric acid. It was afterwards repeatedly extracted with a boiling mixture of alcohol and water, composed of equal parts, by measure, of water and rectified spirit.* The washing was continued until the liquid which passed through the filter ceased to render an acid solution of nitrate of silver opalescent. The insoluble residue was now heated to redness, intimately mixed with about a third of its weight of pure silica, and placed in a small flask, which could be weighed in a balance. To one orifice of this flask, which was furnished with two tubulures, an U-shaped tube was attached, containing fibres of asbestos moistened with concentrated sulphuric acid, as an absorbent of moisture. Very concentrated sulphuric acid, which had been previously boiled, was next added to the mixture in the bottle, and the whole apparatus weighed. Upon now exposing it to a proper degree of heat, gaseous fluoride of silicon ($S F^3$) was evolved, from the quantity of which, as shown by the loss of weight sustained by the apparatus after the conclusion of the experiment, the proportion

* Fluoride of calcium is, to a certain extent, soluble in water, but is very nearly, if not quite, insoluble in dilute alcohol.—T. J. H.



SCALE OF MILES.

of fluorine was calculated. It was generally found necessary, in order to ensure correct results, to remove the last traces of fluoride of silicon from the apparatus by means of an air-pump.

The process just described, it will be immediately seen, is essentially the same as that which was proposed some time since by Professor Wöhler (Poggendorff's Annalen, Band xlviii.). It is, however, the best I am acquainted with, and by adopting the few precautions I have noticed, so far as my own experience goes, I think furnishes correct results.

I will now proceed to detail the numerical results of my analyses, premising that, some few of these have been already made known to the public through the pages of another periodical; but, in order to render the present memoir as complete as possible, it was thought advisable to re-introduce them here.

I. *Phosphatic Earth.*

This mineral, which presented the appearance of a light yellowish-brown powder, was sent to my father for analysis by a gentleman resident in Exeter, who stated that it was found in large quantity in the green-sand and the lower strata of the chalk formations of Sussex and Surrey. Some facts, however, that have been recently brought under my notice induce me to believe that it was nothing more than the powdered coprolites from the Suffolk crag.

The specific gravity, at 60° F., was 2·981.

The percentage composition was as follows:—

Water	3·400
Organic matter	traces.
Silica, with some silicate of alumina and silicate of iron	13·240
Chloride of sodium	traces.
Sulphate of soda	ditto.
Carbonate of lime	28·400
Carbonate of magnesia	traces.
Sulphate of lime	0·736
Phosphate of lime (tribasic)	21·880
Phosphate of magnesia	traces.
Perphosphate of iron ($2Fe^2 O^3 + 3PS^5$)	24·760
Phosphate of alumina	6·998
Phosphate of manganese	traces.
Fluoride of calcium	some.
Loss	0·586
	100·

II. *Pseudo-Coprolites.*

α. The following are the analyses of two phosphoric nodules from the coast of Suffolk. They were of an oval form, and

weighed between 600 and 700 grains each; their external surfaces were much water-worn and highly polished. They were brownish-ferruginous in colour, easily fractured, and, when triturated in an agate mortar, yielded a yellowish-red powder.

Density, at 60° F., 2·815 or 2·850.

Composition per cent.:—

Water, with a little organic matter	4·000	3·560
Salts soluble in water (chloride of sodium and sulphate of soda)	traces.	traces.
Silicic acid, coloured red by a little undecomposed silicate of iron	5·792	6·309
Carbonate of lime	10·280	8·959
Carbonate of magnesia	a trace.	a trace.
Sulphate of lime	distinct traces.	0·611
Phosphate of lime (tribasic)	70·920	69·099
Phosphate of magnesia	traces only.	traces.
Perphosphate of iron	6·850	8·616
Phosphate of alumina	1·550	2·026
Oxide of manganese	traces.	0·016
Fluoride of calcium	0·608	0·804
	100·	100·
Nitrogen, per cent.	0·0254	undetermined

β. This specimen was brought from the same part of the coast as the preceding, but differed from them in possessing a more irregular form, and in exhibiting imperfect evidences of a bony (?) structure.

It was found impossible to determine its specific gravity, in consequence of the presence of numerous air-cavities.

Analysis showed it to possess the subjacent per-centage composition:—

Water, driven off at from 300° to 350° F.	2·600
Water and organic matters expelled at a red heat	9·000
Chloride of sodium, &c.	evident traces.
Carbonate of lime	39·500
Carbonate of magnesia	0·520
Sulphate of lime	distinct traces.
Phosphate of lime	15·860
Phosphate of magnesia	traces.
Perphosphate of iron	9·200
Phosphate of alumina	4·708
Peroxide of iron	none.
Alumina	6·212
Fluoride of calcium	1·698
Silicic acid	10·601
	99·899

The proportion of nitrogen was not estimated.

γ. These pseudo-coprolites were very similar in appearance to those described under *α*, but were obtained from a different source. They were kindly presented to me by the late Mr. Weddell, of Aldborough, having been collected in the neighbourhood of Sutton, in Suffolk,

Their densities were respectively 2·7216 and 2·7891, whilst their composition per cent. was as follows:—

Water and organic matters . .	7·200	9·210
Chloride of sodium and sulphate of soda	traces.	traces.
Carbonate of lime	18·514	5·176
Carbonate of magnesia . . .	0·855	2·016
Sulphate of lime	some.	1·161
Phosphate of lime	51·018	45·815
Phosphate of magnesia . . .	traces.	some.
Perphosphate of iron . . .	8·902	12·476
Phosphate of alumina . . .	2·700	6·387
Oxide of manganese	0·057	0·267
Peroxide of iron	—	—
Alumina	—	—
Fluoride of calcium	3·161	2·688
Silicic acid and loss	7·593	14·804
	100·	100·
Nitrogen, per cent.	0·0289	0·01989

δ. Three other specimens, received at different times from other parties, contained, of—

	Per Cent.		
Earthy and other phosphates .	64·056	79·545	67·176
Fluoride of calcium . .	0·311	2·554	2·768
Nitrogen	traces	0·0314	undetermined.

III. *True Coprolites.*

α. This coprolite was obtained from the lias of Lyme Regis, in Dorsetshire, and was presented to me by my friend Mr. Barker, of Budleigh Salterton. It was rather large, being above nine ounces in weight, was of a grayish colour, and, when broken, exhibited some traces of a crystalline structure. It was considerably softer than any of the pseudo-coprolites above described, and furnished a grayish-white powder. Many scales of different extinct fishes and other organic remains were to be perceived on the external surface; the greater proportion of them appeared to belong to a species of fish which is known to ichthyologists by the name of *Pholidophorus limbatus*.

Its density was about 2·644 or 2·700, and its composition per cent. was as follows:—

	I.	II.	Mean.*
Water and organic matter	6·240	6·124	6·1820
Chloride of sodium and sulphate of soda	traces.	traces.	traces.
Carbonate of lime	23·640	23·708	23·6740
Carbonate of magnesia	none.	none.	none.
Sulphate of lime	1·740	1·801	1·7705
Phosphate of lime	60·726	60·813	60·7695
Phosphate of magnesia	a little.	a little.	a little.
Perphosphate of iron	3·980	4·135	4·0575
Phosphate of alumina	a little.	a little.	a little.
Peroxide of iron	2·094	1·894	1·9940
Alumina	none.	none.	none.
Silicic acid, with fluoride of calcium, and loss	1·580	1·525	1·5525
	100·	100·	100·

The proportion of nitrogen amounted to 0·0826 per cent.

β. Below are given the results of my analysis of another saurio-coprolite, very similar in appearance to the preceding, which was likewise obtained from Lyme Regis.

Density, at 60° F., 2·799.

It was composed in the 100 parts of—

Water	3·976
Organic matters	2·001
Carbonate of lime	28·121
Carbonate of magnesia	0·423
Sulphate of lime	2·026
Phosphate of lime, Phosphate of magnesia	53·996
Perphosphate of iron	6·182
Phosphate of alumina	1·276
Fluoride of calcium	Quantity not determined, but very appreciable.
Silicic acid	0·733

γ. A fragment of a large coprolite, which I bought from a dealer in minerals at Clifton, was found to contain—

Water and organic matter	9·3616
Chloride of sodium, &c.	traces.
Carbonic acid	15·9348
Sulphuric acid	1·2735
Phosphoric acid	22·2275
Lime and magnesia	44·4695
Oxides of iron and manganese, with alumina	2·4549
Fluoride of calcium	1·3679
Silicic acid	2·1106
	99·2003

The person, from whom I purchased this specimen, could not inform me from what locality it originally came.

* In the first of these analyses, the phosphoric acid was estimated by M. Schultze's method, as perphosphate of iron; in the second, as phosphate of lead.

δ. An ichthyo or fish-coprolite, from Tenby, presented to me by Mr. Barker, when separated carefully from the surrounding matrix, was found upon analysis to contain—

Water	11·400
Carbonic acid	16·544
Sulphuric acid	1·186
Phosphoric acid	15·4016
Lime	23·4914
Oxide of iron	7·4737
Alumina	5·7033
Silica and fluoride of calcium	18·8000
	100·

The matrix, on the contrary, contained only 0·1263 per cent. of phosphoric acid.

IV. *Fossil Bones.*

The majority of these remains which I have examined were obtained from the bone quarries in the neighbourhood of Sutton, in Suffolk, by the late Mr. Weddell, of Aldborough, by whom they were kindly presented to me.

The sample which this gentleman forwarded to me evidently consisted principally of bones of extinct cetaceans; and the fossils could be readily divided into two classes, according to the appearance they presented. The bones of the first class (α) were very frangible, and possessed a somewhat porous or spongy texture, caused by the existence of numerous minute cavities or air-tubes in the substance of the bone; whilst those of the second class (β), on the contrary, were very solid, and possessed a fibrous structure. They were much harder than the former, and readily took a fine polish. The air-cells in the latter were invisible to the unassisted eye, and could only be detected by examining thin sections of the bone under the microscope.

α. Annexed are the results of two separate analyses of these bones.

——	——	——	Mean.
Water driven off at 300° to 350° Fahr.	3·361	2·912	3·1360
Water and organic matters expelled at a red heat	4·351	3·361	3·8560
Carbonate of lime	27·400	23·800	25·6000
Carbonate of magnesia	0·371	0·286	0·3285
Sulphate of lime	0·514	traces	0·2570
Phosphate of lime, with some phosphate of magnesia	49·632	56·966	52·8490
Perphosphate of iron	6·600	4·800	5·7000
Phosphate of alumina	3·400	4·638	4·0190
Fluoride of calcium	3·657	undetermined	3·6570(?)
Silicic acid	0·626	0·098	0·3620
	99·912	. .	99·7645
Nitrogen, per cent.	0·1244	undetermined.	

β. I have given below the numerical results of the analyses of three different specimens:—

Specific gravity	2·644	2·874	2·907	Mean.
Water driven off at 300° or 350° Fah.	2·000	2·760	1·976	2·2453
Water and organic matters expelled at a red heat	4·786	5·321	4·679	4·9287
Carbonate of lime . . .	21·000	16·400	17·600	18·3333
Carbonate of magnesia . .	1·089	0·252	some	0·4470(?)
Sulphate of lime . . .	0·298	a little	0·896	0·3980
Phosphate of lime . . . / Phosphate of magnesia . .	58·781	61·175	62·721	60·8923
Perphosphate of iron . . .	6·600	9·400	5·200	7·0660
Phosphate of alumina . .	1·200	0·400	2·416	1·3350
Fluoride of calcium . . .	undetermined	undetermined	4·167	4·1670(?)
Silicic acid	0·120	0·261	0·200	0·1700
	..	..	98·855	99·9826
Nitrogen, per cent. . . .	undetermined	0·0838	0·0482	..

Table I. (page 102) and table II. contain my results in a condensed form :—

Fossil Bones.—Table II.

Number	1.	2.	3.	4.	5.
Specific Gravity	2·6440	2·8740	2·9070	2·5680	undetermined
Water driven off at 300°–350° Fahr. .	2·0000	2·7605	1·9765	3·3611	2·9119
Water and organic matter (by a red heat)	4·7861	5·3210	4·6796	4·3511	3·3616
Carbonic acid	9·8108	7·3480	7·7440	12·2503	10·6218
Sulphuric acid	0·1752	a little	0·5270	0·3024	traces
Phosphoric acid	30·9761	32·9856	32·9141	28·3359	32·9278
Lime	43·3687	42·0962	44·1061	42·1204	41·4636
Magnesia	0·5086	0·1200	some	0·1767	0·1362
Oxide of iron	3·4738	4·9474	1·8943	3·4738	2·5264
Oxide of manganese	..	some	..	some	..
Alumina	0·3892	0·1298	1·0600	1·1027	1·5041
Fluoride of calcium	4·1670	undetermined	undetermined	3·6571	undetermined
Silicic acid	0·1121	0·1610	0·1992	0·6160	0·0980
	99·7676	..	..	99·7475	..
Nitrogen	undetermined	0·0838	0·0482	0·1244	undetermined

The facts which I consider have been proved by the preceding analyses are—

1st. That the pseudo or false coprolites of the Suffolk and Surrey crag are as rich in phosphoric acid as the true icthyo and saurio coprolites of other formations.

2nd. That the proportion of phosphoric acid in the pseudo-coprolites and phosphorites varies from about 12·5 to 37·25 per

TABLE I.

Coprolites, &c.

	Phosphatic Earth.	Pseudo-Coprolites.					Large Saurio Coprolites.	A fragment of a Saurio Coprolite.	An Ichthyo or Fish Coprolite.
Locality	?	Suffolk.			Sutton, Suffolk.		Lyme Regis, Dorsetshire.		Tenby, South Wales.
Specific Gravity . .	2·9810	2·815 to 2·850		Undetermined.	2·7216	2·7891	2·7000	Undetermined.	Impossible to determine.
Water driven off at 300°–350° Fahr. .	3·4000	4·0000	3·5600	2·6000	7·2000	9·2100	2·6140	9·3616	1·6000
Water and organic matter (by red heat) .				9·0000			3·5680		9·8000
Chloride of sodium . Sulphate of soda .	traces	traces	traces	traces	..	..	traces	traces	..
Carbonic scid . . .	12·4960	4·5232	3·9420	17·6523	8·5910	3·3334	10·4165	15·9348	16·5440
Sulphuric acid . .	0·4330	evident traces	0·3594	evident traces	Some	0·6829	1·0417	1·2735	1·1860
Phosphoric acid . .	26·6150	36·8890	37·1600	12·4090	29·3006	30·7540	29·9690	22·2275	15·4016
Lime	27·9890	43·8918	42·4436	32·6920	37·8394	28·0466	46·7000	44·4695	23·4914
Magnesia	traces	traces	traces	0·2477	0·4100	0·9600	traces		..
Oxide of iron . . .	13·0320	3·6060	4·5350	4·8420	4·6850	6·5664	4·1295	2·4549	7·4737
Oxide of manganese .	traces	traces	0·0160	..	0·0570	0·2671	..		..
Alumina	2·2090	0·6800	0·8680	8·1560	1·1630	2·6880	a little		5·7033
Fluoride of calcium .	traces	0·6080	0·8040	1·6980	3·1610	4·1011	1·5525	1·3679	18·8000
Silicic acid, &c. . .	13·2400	5·7920	6·3090	10·6010	7·5000	12·6910		2·1106	
	99·4140	99·9900	99·9970	99·8980	99·9070	99·2905	99·9912	99·2003	100·0000
Nitrogen	undetermined	0·0254	..	undetermined	0·0289	0·01989	0·0826	undetermined	undetermined

cent.; the average proportion, however, being about 32 or 33 per cent.:* consequently, leaving the nitrogen and other constituents out of consideration, powdered coprolites may be said to possess at least an equal agricultural value with the bones of animals.

3rd. That the proportion of fluoride of calcium present in these phosphorites varies exceedingly, sometimes occurring only in traces, whereas at others it amounts to as much as 4.1 per cent.

4th. That the fossil bones of the crag are generally richer in phosphoric acid than normal bones, and, therefore, are equally well, if not better, adapted than them for the fertilization of land.†

5th. That the proportion of fluorine which is met with in the bones of extinct animals and fishes is considerably greater than that in those of any species now in existence.‡

Fossil bones, as an average, contain, according to my experiments, 3·912 per cent. of fluoride of calcium, whereas the bones of species of animals now in existence, according to Berzelius, contain it only in very small quantity, certainly not more than 1 per cent.

6th. That the proportion of phosphates and fluoride of calcium is greater in the hard and solid bones than in those which possess a more open and spongy texture.

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* According to the results of previous experimenters these nodules contain—

From 24 to 25 per cent. of phosphoric acid		(Mr. Way).
,, 25 to 26	,, ,,	(Dr. Gilbert).
,, 22·2 to 28·74	,, ,,	(Mr. Nesbitt).

† The following table contains the results of the most recent experiments of Prof. Marchand, and shows the proportion of phosphoric acid and phosphates which is met with in the bones of different animals:—

Bones in their normal state.

	Ox Bones.		Sheep.		Human.	
Phosphate of lime (3 Ca O, PO^5).	58·30	$=PO^5$ 28·04	62·70	$=PO^5$ 29·80	59·90	$=PO^5$ 28·30
Phosphate of magnesia. (3 Mg O, PO^5).	2·09		1·59		1·22	

The proportion in the bones, after being deprived of organic matter, was as follows:—

	Ox Bones.		Sheep.		Human.	
Phosphate of lime	83·07	$=PO^5$ 39·96	84·39	$=PO^5$ 40·12	85·73	$=PO^5$ 40·52
Phosphate of magnesia	2·98		2·15		1·74	

No analyses of the bones of cetacean animals have been published.

‡ In the bones which he examined, Middleton found a much larger amount of fluorine. The proportion of fluoride of calcium per cent. was as follows:—

Colossochylus atlas of the Sewalic Hills	11·68
Fossil ruminant of the Sewalic	10·65
Fossil horse of ditto	11·24
Fossil camel of ditto	11·16
Fossil alligator of ditto	4·85
Iguanodon of the Wealden	11·51
Not fossilized: Greek skull (2000 years old)	5·04
Not fossilized: Skull of an Egyptian mummy	2·34
Not fossilized: Recent skull	1·88 to 1·99

7th. That the proportion of nitrogen contained in fossilized bones is only very minute; and it is therefore clear that, during the process of fossilization, the nitrogenous or gelatinous part of the bones becomes dissolved out from the earthy and insoluble portion, or is decomposed by the oxidizing action of the air and dissipated in the form of gas.*

Besides the above, I have also been enabled to determine another interesting fact; namely, that the phosphoric acid and fluorine occur in largest proportion in the external layers of the pseudo-coprolites. Thus, the most external portion of one of these nodules contained—

1·105 per cent. of fluoride of calcium, and
40·019 per cent. of phosphoric acid;

whereas the central portion contained only

0·611 per cent. of the fluoride, and
34·015 per cent. of phosphoric acid.

In the second specimen which was examined in this way the differences were still more strongly marked. The results were as follows:—

	Exterior portion.	Interior portion.
Fluoride of calcium . . .	3·996 . .	1·961
Phosphoric acid	32·043 . .	21·046

Now, the above results would certainly go far to prove the correctness of Dr. Buckland's views with regard to the mode of formation of these strange fossils. According to Drs. Buckland and Playfair, the phosphoric nodules in question originally consisted of marl-stone, chalk, or soft limestone, and became impregnated with phosphoric acid only by long-continued contact with decomposing animal exuviæ and other organic matter. Lime possessing a greater affinity for phosphoric acid than it does for carbonic acid, a kind of exchange of elements, or pseudomorphic

* The same result was arrived at by M. Marchand. This chemist analysed two specimens of the fossil bones of a species of bear: one of these (I.) had been found on the surface of the soil; the other (II.), on the contrary, had been dug up from a considerable depth. The following are the results of his analysis:—

	I.	II.
Organic matter	4·20	16·24
Phosphate of lime	62·11	56·01
Carbonate of lime	13·24	13·12
Sulphate of lime	12·25	7·14
Fluoride of calcium	2·12	1·96
Phosphate of magnesia	0·50	0·30
Silica	2·12	2·15
Oxides of iron and manganese . . .	2·12	2·00
Soda and loss	1·34	1·08
	100·	100·

Here it will be seen that the bone which had been exposed to the action of the air contained only a little more than one-fourth as much organic matter as the other.

conversion of carbonate into phosphate of lime, took place, and they suppose that it was in this way that the phosphorites were formed in all the strata of the crag. The nodules having been imbued with phosphoric matter "from their matrix in the London clay," writes Dr. Buckland, "they were dislodged by the waters of the seas of the first period, and accumulated by myriads at the bottom of those shallow seas where is now the coast of Suffolk. Here they were long rolled together with the bones of large mammalia and fishes, and with the shells of molluscous creatures that lived in shells. From the bottom of this sea they have been raised to form the dry lands along the shores of Suffolk, whence they are now extracted as articles of commercial value and ground to powder in the mills of Mr. Lawes, at Deptford, to supply our farms with a valuable substitute for guano, under the accepted name of coprolite manure."

Dr. Buckland has even proposed to take advantage of this curious property which is possessed by calcareous matter, and render it of service in the production of a similar manure from the sewage and sewerage-water of large cities. He says he has no doubt that the addition of carbonic acid to sewage, and protoxide of iron and salt, with a moderate heat, would induce conditions approaching to those under which analogous compounds were formed from putrescent animal and vegetable matter in ancient deposits, both under salt and fresh water, throughout all geological time.

The only serious objection to this scheme lies in the long period of time that would be required in order to effect the desired conversion.

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Mansion-House, Old Park, Bristol,
July 17, 1851.

V.—*Essay on the Cultivation of Oats.* By JOHN HAXTON.

PRIZE ESSAY.

THE cultivation of oats is very general throughout the whole of Scotland, Ireland, and the North and West of England. In the two former countries it forms a prominent feature in nearly every rotation of crops, and although less so in the districts of England referred to, the practice is sufficiently common to warrant us in classifying them along with Scotland and Ireland, as possessing a soil and climate adapted to the special requirements of the oat

plant. Scotland, however, may be considered as the proper type of an oat-growing country. Its climate is cool—the mean maximum temperature of July not exceeding 68° Fahr. in ordinary years, even in the warmest parts of the country; and the soil is generally well adapted to the growth of oats—there being no chalk deposits like those of Surrey and Wiltshire, and a very inconsiderable amount of sands like those that prevail in the county of Norfolk.

The meteorological influences which affect the growth of the oat plant, differ considerably from those that control that of wheat and barley; so much so, that the very causes which conspire to render its cultivation more successful in Scotland and Ireland than in South England, give these countries a climatic character far less favourable to the growth of wheat and barley. We have only to glance at the market prices of the different descriptions of grain in each country in order to be made aware of the fact, that the wheat and barley grown in proper soils to the south of the Humber, excluding the Fens, are as superior to those grown to the north of the Tweed, as the oats of the latter country are to those of the former. The geological characters of the two districts of country alluded to are, no doubt, considerably different, but they are not sufficiently so to account for the fact that the more northerly produces, even with very ordinary cultivation, excellent crops of oats both as to quality and quantity. The fact also that the cultivation of oats becomes more successful as we proceed northward and westward in England, leads to the inference that the increased capabilities of these districts for growing this grain are due in a great measure to climatic causes, and not to the physical or chemical nature of the soil. This position will appear the stronger, if we take into consideration the extraordinary results that have been produced by certain climatic aberrations which have occurred within the period of the present century. The hot, dry summer of 1826, rendered the oat crop in Scotland an extremely light one, especially in the drier districts, but in the cold high-lying land where the maximum temperature was more moderate, it was an average crop; and in some cases where the land was in good order, even considerably above it. The wheat crop of 1826, on the contrary, was the finest ever seen in Scotland, and bore a marked resemblance to the superior quality of that grown in South England in moderately warm years. These facts show the influence of climate on the productions of a country, and although the case adduced in illustration is no doubt an extreme one, it proves that similar atmospheric causes produce similar results irrespective, in a great measure, of the geological character of the soil, and that the nearer the climatic conditions of Scotland in any year, approach to those common to South England, the worse is the crop of oats and the better the produce and quality

of wheat and barley in the former country. In other countries too, both on the continents of Europe and America, lying within the same parallels of latitude as Scotland and the North of England, the crops of oats are always inferior owing to the high range of summer temperature that prevails. We may safely conclude, therefore, that the northern parts of Britain, and nearly the whole of Ireland, owe their oat-producing capabilities primarily to their insular position, and secondarily to their mountainous character—a combination which not only occasions the existence of a large amount of aqueous vapour in the atmosphere, but also insures its deposition on the ground in the form of refreshing rains, mists, and dews.

But natural causes originating in the soil and climate are modified in their results by cultivation, and hence we may infer that as improved practices in husbandry have rendered Scotland better adapted to the growth of wheat and barley than it was fifty years ago, so may they modify the effects of the soil and climate of South England, and render the cultivation of oats, where that is desirable, a matter of greater certainty and success than it has hitherto been.

From what has been said it will be seen that the successful cultivation of oats depends more upon a moderate degree of temperature and moisture in the atmosphere than upon the nature of the soil; and as a proof of this we find that good farming produces good crops of oats on nearly all varieties of soil in Scotland. Of course there are some soils naturally better adapted to their growth than others, and there are also certain districts where one variety of oats succeeds while another fails, but neither of these affects the point in question—they only prove that there are differences of degree in the success attending the cultivation of a crop. We shall therefore proceed to consider in detail the several classes of soils upon which oats may be grown successfully, and those also, comprising a very few, that are not adapted to their growth.

Soils best adapted to the Growth of Oats.—The best soils for the earlier varieties of oats, such as the Potato Oat, Sandy, Sherriff, Hopetoun, &c., are those derived from the alluvial deposits of the trap and new red sandstone formations which form the lower parts of valleys, and the more level portions of the country, where these rocks abound. The richer class of granite soils are also well adapted for early oats. As a general rule we may state that wherever a soil has been formed by the alluvium of rocks or strata not characterised by the presence of too great an amount of aluminous or clayey matter, there we have a soil which, if drained and in proper condition, will produce excellent crops of the finer varieties of oats. The county of East Lothian, mostly consisting

of alluvial loam, with partial outbursts of trap through the surface, produces oats of a quality so superior as to weigh 44 to 46 lbs. per bushel, while the yield often reaches 10 and 12 quarters per imperial acre. The county of Fife, situated on the opposite side of the Firth of Forth, also produces fine crops of oats. The southern part of this county is similar in many respects to the Lothians—the soil being composed of a mixture of trap *débris* and red and yellow sandstone deposits. The northern portion is entirely composed of the various kinds of trap, greenstone, basalt, amygdaloid, and porphyry, sometimes distinct and isolated, but more commonly blended together. All soils derived from these rocks are more or less productive of oats, and even the thinner and drier portions towards the upper parts of the hills yield bulky crops of oats if sheep-folded, and laid down two years to grass. The lower parts furnish a deep rich alluvium upon which excellent crops can be grown with little trouble or expense.

The mountain limestone soils also produce good crops of oats, but they require to be more highly manured than the freer traps and loams. When properly drained, and otherwise in good condition, these yield large crops of oats, but the quality of the grain is never equal to that obtained on those first-mentioned. In dry summers, however, the mountain limestone soils are often more productive of oats than the drier and freer ones are, owing to the more retentive nature of the subsoil.

On the clay soils of the Carses of Gowrie and Stirling, derived principally from the old red sandstones, the cultivation of oats is very precarious, and the yield greatly depends on the character of the seed time. When the ground has been properly mellowed by exposure to frost, the sowing season dry, and the summer not too wet, very heavy crops of oats are obtained on *Carse* land, but unless all the circumstances be favourable the oat crop is sure to prove an inferior one, and hence it does not occupy so prominent or important a position in the rotations followed on such soils as wheat. Oats are found to succeed best on clay land, after a crop of red clover, and the stronger the clover is, the better is the corn. The roots of the clover, no doubt, tend greatly to open up the soil, and to render it more friable and less apt to consolidate around the tender rootlets of the oat plant. Whenever we get beyond the edge of these clay basins we find a much lighter soil lying on the outskirts, where the cultivation of oats becomes highly successful, and on which this crop may be allowed to form a regular part of the rotation.

The soils in England which are analogous in their agricultural character to the Carses of Scotland are the Wealds of Kent, Surrey, and Sussex, the Gault of Cambridge and Huntingdon-

shires, and the different varieties of clay denominated London and Plastic clays. On all these soils it is desirable to introduce oats into the rotation of cropping, because of their unfitness for the production of barley. Wheat and beans are the principal crops cultivated, and could oats be profitably grown, their introduction would serve the purpose of varying and lengthening out the course of cropping. The better portions of these clay soils, when properly drained, are well adapted to the growth of oats, but on the stiffer, stronger, and more tenacious class, it becomes exceedingly precarious. Draining and liming would greatly modify their stubborn character, and enable the farmer to grow oats upon them as well as wheat and beans. The proper position for the oat crop, when cultivated on clay soils, is after red clover, and the ground should be ploughed early in winter, in narrow ridges, in order that it may obtain the benefit of frost, and thus become mellow and friable before seedtime. The seed should be sown broadcast, for the sake of expedition, when the weather is propitious, at the rate of four bushels to the acre, and harrowed in as dry as possible.

The Fen lands of Lincolnshire, Cambridgeshire, and the adjoining counties, have long been famed for the excellence of the crops of oats raised upon them, especially where they have been drained and clayed. These fens furnish an illustration of the fact that a certain degree of depth and dampness in the soil is equivalent to, and can compensate to the plants growing upon it for a high temperature and a lack of moisture in the atmosphere. All deep alluvial soils, rich in vegetable matter, wherever situated in the British Islands—excluding, of course, those isolated deposits on the higher elevations—when drained and limed, or pared and burned, when there is an excess of undecomposed vegetable matter, are peculiarly adapted to the production of oats. They naturally possess, from their vegetable origin, the property of capillary attraction in a high degree, and even when thoroughly drained, they still preserve the requisite amount of moisture to supply the plants with food in dry weather, while at the same time they are less liable to be injured by an excess of rain than heavy clay soils which bake with drought, and become soured by long continued rains. In a wet or cold climate oats are the only grain crop that can be cultivated with success on soils formed principally of vegetable mould, and consequently we find this to be the case generally in Scotland and Ireland, but in England, where the fen lands enjoy a good climate, and are situated on the *clunch*, or Oxford clay, the cultivation of wheat can also be profitably carried on by claying the surface.

The most sterile soils for oats are those composed of loose calcareous matter, such as the upper chalks of England, and also

sands and gravels of an incohesive texture. It has long been remarked in the case of light soils long under cultivation, that a second application of lime, if not injurious, is at least not beneficial to the oat crop; and that an overdose of caustic lime, or of purely calcareous chalk, is frequently productive of the worst results. Several instances of this have come within the writer's observation. On a light trap soil that had been once overlimed, the oat crop for several rotations of five years' interval, lost its green colour, and turned brown when the plants were in the shot-leaf; and this occurred independently in a great measure of the character of the season; and although the evil was undoubtedly more aggravated by a continuance of dry weather at the time, yet an abundance of rain did not prevent the plants from becoming *scorched*, as it is usually termed. Other instances might be mentioned of light gravelly soils being rendered incapable of growing oats for a long time in consequence of having received a heavy top-dressing of very rich calcareous shell marl found in beds under a layer of peat. Such effects are seldom observable on deep alluvial soils—whether composed of clay, loam, or black mould—but on all light soils composed principally of gravel, sand, loose brown earth, or decomposed peat long under cultivation, lime should be very sparingly used, as an overdose is fatal to the success of the oat crop. These soils are naturally too loose in their texture, and this evil is greatly aggravated by the use of too much caustic lime or even of shell marl. So far as the writer's experience and observation extend, the practice of liming loose mossy, or gravelly soils, long under cultivation, has always proved injurious to the oat crop for a long time afterwards; and as on the former of these this is the only grain that can be profitably cultivated, it becomes the more necessary to avoid an error so hurtful to their fertility. In reclaiming peaty soils at first, the use of lime is quite indispensable, in order to decompose the inert vegetable matter, and neutralize the tannic, ulmic, and humic acids they contain; but after the soil is fairly formed, and has been reduced to a mass of loose black mould by cultivation and a course of cropping, the use of bone manure is greatly to be preferred either to caustic lime or shell marl. The use of *clay* marl, on the contrary, may very properly be adopted on *all* light soils, as it carries along with it its own antidote in the shape of a large proportion of aluminous matter, which renders the soil to which it is applied more cohesive, and consequently more absorbent and retentive of moisture.

There are also several kinds of moory soils on which oats refuse to grow, especially those lying on a subsoil of mixed clay, sand, and oxide of iron, hardened together by infiltration from above, and known as *Moor-band* soils. Both wheat and barley can be

grown with tolerable success on such soils, but the cultivation of oats is a thankless and unprofitable task. In such cases the use of caustic lime is not only admissible but highly useful when draining and subsoiling have preceded it, but even when all these means have been brought to bear on a real moor-band soil, the result as regards the oat crop is not by any means satisfactory.

From these general remarks on the comparative capabilities of different soils for producing oats, the following classification may be adduced—proceeding in the descending scale of their fertility.

First Group.—Rich, friable, reddish-coloured loams, of which the Lothians and Berwickshire in Scotland, and Devon, Somerset, Hereford, and Gloucestershires in England afford specimens. These soils are generally easily drained, and are either of alluvial origin or derived from the new or old red-sand-stones or basalt as in Scotland, or as occurs in England from the green-sand formation.

Rich, black loams found at the base of trap hills. Where the rock is porphyritic the soil is generally of a red colour, and leaves a deep stain on cloth not easily removed. The northern part of Fifeshire affords the best specimens of the various descriptions of trap soils. The oats grown on these soils are always of excellent quality and the produce abundant.

Fen land that has been drained and clayed, as in Lincolnshire, where the large quantity of grain yielded makes up for deficiency in quality.

Second Group.—Clay land that has been limed and furrow drained.

Medium trap, whinstone-soils.—These require to be folded and pastured by sheep to improve their consistency.

Light, loamy land, requiring also to be mechanically consolidated either by treading with sheep or by the press-roller.

Reclaimed peat or moss land that has not been clayed. Common in Scotland and Ireland and might be greatly improved, where clay cannot be obtained, by a thick coating of sand or gravel.

Third Group.—Thin gravelly soils left by the infiltration of water.

Poor whinstone soils, situated on the higher acclivities of the greenstone trap hills.

Loose sandy land, as in Norfolk, and what are termed *links* in Scotland.

Loose calcareous soils, as the upper chalk of the south of England.

Cold poor clays, as in Huntingdon and Cambridgeshires.

There are innumerable varieties of soils less or more adapted to the growth of oats, which would occupy too much space to par-

ticularise; but we may mention that many of the granite soils of Aberdeenshire produce good crops of oats, so also do the better and thicker portions of the blue lias and oolite soils of Gloucestershire. These may be ranked in the secondary class of oat-producing soils, while the poorer portions of the same formations cannot be placed higher than the third and last group.

The two first groups are all, with the exception of reclaimed peat, well adapted for the growth of wheat as well as oats, when situated in a sufficiently dry and warm climate.

The soil and climate of East Lothian are admirably adapted to the growth of all the cereals, leguminous, and root-crops; but were these disjoined, and a summer climate like that of the south-eastern part of England substituted, there would be a marked diminution in the quantity and quality of the oat-crop, so much does its success depend upon a moderately low summer temperature. Again, were the fens of Lincolnshire exposed to a climate like that of Aberdeenshire, it would be found impossible to grow wheat upon them with any degree of success. We see therefore that the classification of soils according to their capabilities of producing any particular crop can only be correct when the circumstances of climate, including light, heat, and moisture, are nearly equal. Thus, for example, the light turnip land of Norfolk produces crops of oats so inferior as would at once assign it a very low place in the scale, but were the hot, dry summers of that county exchanged for the moist, cloudy skies of the west of Scotland, the increase of straw and grain would be so great as to raise such land to a secondary position at least in a classification of oat-producing soils.

The 3rd group of soils are all more or less sterile for oats even when the conditions of climate are favourable, and it is only by the highest cultivation, or by remaining long in pasture, that they can be made to yield an average crop. In Scotland and Ireland there are almost no chalky soils, like those of south England, so that we are unable to determine their capability to produce oats in a cool, moist climate; but in both of these countries abundance of loose gravelly soils, sandy land, and thin *traps* abound, and it is only when the season is peculiarly favourable that the cultivation of oats is successful. If therefore it is a difficult and oftentimes ungrateful task to grow oats on such soils in a cool and moist climate, what must it be on the dry burning soils of Norfolk, or the chalky downs of Surrey and Wiltshire? We arrive, therefore, at the conclusion that unless some particular inducement to cultivate oats on the lighter class of soils in south England presents itself, any attempt to introduce this crop into a rotation, to the exclusion of wheat or barley, will prove unremunerative. Besides, it is a generally understood fact that oats

grown in a dry climate exhaust the soil more than wheat or barley.

We may add, finally, with regard to the lowest group of oat-producing soils,* especially the lighter descriptions, that the easiest and cheapest way to increase their fertility is to pasture them two or three years with sheep every rotation, and when turnips can be grown, to use bone-dust for manure, and consume the whole crop *in situ*.

On all soft soils, composed either of black earth, soft loam, or reclaimed peat, the cultivation of oats necessarily occupies a prominent position. On these soils the cultivation of barley is almost excluded, owing to their tendency to produce an excess of straw injurious to the development of the grain. Wheat can be grown with tolerable success on black land or soft loams situated in a dry warm climate, but only at greater intervals than would be required on harder and more clayey soils. Here then are special cases where the systematic cultivation of oats becomes indispensable as the principal means by which an alternate course of cropping may be carried on. In Ireland the main grain-crop on all soft soils is oats, and even on hard land barley

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* All the best farmers in Huntingdonshire and Cambridgeshire adopt the Norfolk, or four-course, system; and when they grow oats, they always grow them as the fallow-crop; and I have seen many fine crops, of good quality, grown after turnips in the county of Norfolk. But upon strong, poor, sterile *clay land*, well drained, no crop will pay better than the oat-crop after the summer fallow, which will produce on this description of soil eight to ten quarters of the Black or White Tartarian sorts to the statute acre. And it has long been a known fact, that wheat cannot be grown to advantage, even on clay land, oftener than once in four years. The system that has been adopted for some years by the best farmers of strong land in this county (Bedfordshire) is one that may be continued with advantage for time *ad infinitum*, that is, one-eighth of the fallows to be a summer or dead fallow, the other one-eighth to be sown with winter tares, soiled with sheep, and then fallowed in the same manner. The next year the one-eighth that was summer fallow to be sown with oats, and seeded down; and the other one-eighth, that was tares, to be sown with barley, and *not seeded*, but after the barley to be sown with beans, the other being seeds. At Michaelmas the two one-eighths, or one-fourth, to be wheat. Care should always be taken to seed down only the part that was summer fallow, as seeds never flourish after tares. From long experience and observation, I have noted that, if you should by chance get a plant of clover after where the tares grew the year before, it will not produce either keep or hay; therefore it is obvious the tares take from the soil what is needful for the nourishment of the clover plant. Care should also be taken that the course of tares and dead fallow should be changed the next four years (or course), and then the land will never be clover or seeds oftener than once in eight years.

The time of sowing the spring crop (after the fallow) should be named. It must entirely be regulated by the weather, care being taken never to lose an opportunity when the land is sufficiently dry to work, after the commencement of the new year.

The writer of this note has sown his barley and oats on poor, cold land (well drained) early in January, and has always succeeded the best when very early. The time to be fixed is whenever the land will work, whether it be in January, February, or the *early part* of March.—S. Bennett.

is seldom sown. The ordinary rotation on well cultivated soils is grass, oats, green-crop, wheat with seeds. In Scotland the rotation on soft, mossy soils is grass pastured two years, oats, turnips, oats with seeds. Were the former of these rotations to be tried in Norfolk the result would be greatly inferior to the common and well known "four-course shift" of that county, because there both the soil and climate are inimical to the growth of oats. We see, therefore, that the long established rotations of different districts are not originated by mere empiricism, but are the results of well-tried experience. Custom too often decides erroneously on the succession in which crops should follow each other, but natural causes, if rightly interpreted, determine those best adapted to a locality. If oats are ever to be regularly cultivated in Norfolk, the present four-course shift must be abandoned for one of a longer duration, as neither wheat nor barley can be dispensed with in a climate so well adapted to their growth. But this point will be more particularly discussed in another section of this article, meantime we will endeavour shortly to notice the more important varieties of oats at present cultivated in the United Kingdom.

Varieties of Oats cultivated in Great Britain.—There are three well-defined groups of oats easily distinguishable by their colour—white, black, and grey or dun. The greatest number of varieties belong to the first class, and these are also the most valuable in an agricultural point of view. White oats are separable into two principal varieties—the early and late—and these again into several sub-varieties characterised by certain peculiarities of growth.

Potato Oat.—This is one of the finest of the early varieties of oats both for quality and quantity of produce. It is probably also the oldest *early* white variety at present in cultivation. It was introduced into Scotland towards the end of last century, but the accounts of its origin are somewhat contradictory. According to a writer in the 'Farmer's Magazine' for February, 1803, potato oats were first imported from South America in a small parcel containing a quantity not greater than would fill an ordinary-sized snuff-box. They were inclosed in a larger package containing potatoes, and hence the origin of their name. Another account states that they were first discovered growing in a field among potatoes in Cumberland in 1788. The latter is Lawson's account; the other that of an anonymous writer. The authority of Lawson is, no doubt, most to be trusted, both from his long experience and his many opportunities of becoming acquainted with facts relating to the origin and introduction of agricultural plants. The grain of the potato oat is white, short, and plump,

when well grown, and the straw is of a pale yellow colour and moderately bulky. The young plants tiller freely when the seed is not too thickly sown, and the stems usually stand remarkably close and carry a large bushy ear, which gives the crop a remarkably luxuriant and rich appearance when fully shot out. The grain weighs from 40 to 46 lbs. per bushel, and it yields more meal per quarter, weight for weight, than any other variety. Instances are within the writer's knowledge where 27 Scotch pecks = $236\frac{1}{4}$ lbs. of meal have been obtained from a quarter of potato oats, and in one case the yield was 28 pecks = 245 lbs. of meal from one quarter. In ordinary years potato oats of 42 lbs. per bushel will yield 24 pecks = 210 lbs. of meal per quarter. When the weight per bushel falls below 40 lbs. in ordinary years, it is a sure indication either that the soil is unsuited to the growth of potato oats, or that proper attention has not been bestowed in changing the seed from a different and better locality.

The best soils for potato oats are black land and reddish coloured loam of a firm but not clayey texture. When such soils are properly managed the yield of grain in good years will often reach 10 quarters, weighing from 42 to 44 lbs. per bushel. This oat is also well adapted for being cultivated on *sharp* trap (whinstone) soils, and also on the better classes of granite soils. On soft, peaty land the crop is apt to lodge, and on light gravelly or sandy soils the grain degenerates very rapidly—a sure indication of which is the development of the awn, or spike, at the thin end. On clay land the cultivation of potato oats is exceedingly precarious, owing to the liability of the young plants to become *sedge-rooted* when there is a superabundance of rain in spring or the earlier part of summer. A considerable experience in growing different kinds of oats has led the writer to choose the potato oat in preference to all others as the most remunerative. The soil is a light brown trap, very thin in some fields, easily made fertile by sheep-folding, with the under-lying rock protruding through the surface in many parts. In moist summers the yield of potato oats is about 6 qrs. per acre, on such land. This oat requires to be cut before it is ripe, as it is very apt to shed its seeds in moderately high winds when quite ripe.

Sandy Oat.—This variety, according to Lawson, was discovered in 1824-5, on the farm of Miltoun of Noth, in the parish of Rhynie, Aberdeenshire, by a herd boy, Alexander (Scotticè Sandy) Thomson, who found it growing on a bank of recently thrown up earth. It was carefully preserved by his master, Mr. Pirie, and propagated from year to year, and now it is extensively cultivated in almost every district of Scotland. The Sandy oat

grows very freely, tall, and stiff in the straw, not easily lodged, nor liable when ripe to shed its seeds so readily as the first named variety. The grain is smaller, and not quite so rich in meal as the potato oat, but it weighs well in the bushel, and is liked by millers. It is not well adapted for feeding horses with, unless when bruised, as the smallness of the grains renders them liable to be swallowed whole. Sandy oats are valuable for sowing on soft mossy soils, where the crop is apt to be laid, and no doubt they would answer well on the Fen lands of England. It is also a better oat for clay land than the potato variety, as it is not apt to become sedge-rooted. When sown alongside of each other on good firm land the potato oat always surpasses the Sandy in quality and produce of grain, but on softer soils the latter is to be preferred on account of the greater stiffness of its straw, which makes excellent fodder. The Sandy oat is also rather earlier than the potato variety, but it assumes a deep yellow colour eight days before it is ripe, while the other is quite ready for being reaped a week before the green colour disappears. The former should not be reaped until the whole crop has assumed a uniform yellow colour; the latter should be cut down when the green and yellow are about equally mixed.

Sherriff Oat.—This variety has only been a few years in cultivation. It has some of the characteristics of the potato oat, a very early maturity and moderate length of straw; but the grain is smaller and very considerably lighter in the bushel; neither is its habit of growth so robust. It is considerably earlier than the two varieties already described, and new parcels of it appear in the Edinburgh market a fortnight before any of the other kinds are ready. Were it not for the lightness of the grain, and its delicate habit of growth, the Sherriff oat would be a valuable kind to sow in late districts. At present it is undergoing the ordeal of experiment in many districts of Scotland, and a few years will prove its merits or demerits. The writer saw a field of Sherriff oats last year, the yield of which was computed by competent judges to be above 76 bushels per imperial acre. But it must be added that the soil was of first-rate quality, and the climate everything that could be desired for the growing of oats.

Hopetoun Oat.—The Hopetoun oat was greatly liked on its first introduction, but now it has so much degenerated that it is scarcely recognizable by Lawson's description. He says, "It is earlier than the potato oat, and not so liable to be shaken by high winds; its straw is longer and not so apt to lodge." The last of these characteristics has entirely disappeared, for now, no variety so easily bends over and becomes straw-broken as the Hopetoun oat. The writer has cultivated Hopetoun oats for many years,

but the grain was never equal to the potato variety either in quality or quantity, although sown under similar circumstances. When bulky the culms *knee* over above the first joint from the ground, and when exposed to very moderate wind or rain the crop goes completely down and presents the appearance of having been passed over by a heavy roller. The best mode of cultivating Hopetoun oats, when not intended for seed the following year, is to mix them in equal proportions with Sandy oats, and sow the two together. The straw of the latter being strong and stiff helps to keep the weaker straw of the former from going down, and the crop thus obtained generally yields better than either variety sown by itself. The Hopetoun oat has a large grain, thick husk, with a yellow purplish or brownish tinge, does not meal so well as the Potato or Sandy. It yields largely to the acre when the crop is not lodged. It is suitable to light soils, but not to exposed or high lying ground. It might be found to suit the light sandy and chalky lands of the south and south-east of England, where there would be no risk of danger to the crop from its being too strong. In Scotland its straw is not much esteemed for fodder, but this may arise in some measure from its being frequently laid flat to the ground and partially rotted before being reaped. No doubt a dry climate would improve the straw of the Hopetoun oat considerably. It ripens much about the same time as the Potato and Sandy oats, but when sown as a mixture the Hopetoun and Sandy do best together.

The other varieties of oats akin to those already described are "Early Angus," short, and rather weak strawed, prolific on rich soils; English Berlie or barley oat, similar to the last, but better strawed. It is a great favourite in Aberdeenshire, from whence it has been imported into Ireland by Scotch agriculturists residing in that country, and found to answer the soil and climate remarkably well.

The Siberian Early White oat is also worthy of notice. It was originally sent to Scotland from Hamburgh by Messrs. J. G. Booth and Co., of that city. The high character sent along with it has scarcely been sustained in this country, for although a very prolific variety, and very early, yet the straw is so coarse as to be fit only for litter, while the grain is enveloped in a thick husk—a sure sign of deficient mealing properties. Oats can never be reckoned a remunerative crop unless the straw will make good winter fodder for horses, sheep, or cattle; and all other circumstances being equal the Scotch arable land farmer always gives the preference to that variety which affords the best straw for this purpose. For these reasons it is not likely that the cultivation of white Siberian oats will ever become general in this country.

Late or Common White Oats.—These differ from the varieties

already mentioned in coming later to maturity, having larger seeds and thicker husks, but yielding better straw for fodder. The "Late Angus Oat," of which a drawing is appended, may be taken as a type of the class generally. It and the Drummond oat are well adapted for clay soils, and neither of them is so liable to shed its seeds in high winds as any of the earlier sorts—the Sandy excepted. The other sub-varieties of this class are Cupar Grange oat, rather later than the two first mentioned; Blainsley oat, resembling the last, and much cultivated in the South of Scotland; and lastly, the Kildrummie oat, considered the most inferior of its class.

Late or common oats, as they are generally termed in Scotland, produce the best crops in that country in warm and rather dry years, on which account they would, no doubt, be found to grow well in the drier and earlier climate of South England. They grow freely on clay soils, and also on light poor soils, but should never be cultivated on loamy land or vegetable mould, as they are apt to produce too much leaf and become lodged. The grain, as before stated, is usually larger, more awned, and has thicker husks than the earlier sorts, but it is highly esteemed for feeding horses with, and the straw makes decidedly the best fodder of any of the cereal grains. In late years common oats are deficient in mealing properties, but in early seasons the husk is much thinner, and the produce of meal proportionally increased. They are remarkably well liked by millers on account of the *flinty* texture of the kernel and the superior quality of the meal they yield. The difference between the meal of the common or late oat and the potato oat is as great as that between the flour of what is termed flinty wheat and that produced from the softer and starchier sorts. The one has a granular roughness which the other is devoid of.

Coloured Oats.—These are black, dun, or grey. The Black Tartarian oat is almost the only variety of the first mentioned sort cultivated in Britain. It differs from all others in carrying its seeds on one side of the ear. The grain is of a shining black colour, much elongated, and when badly grown very much bearded or awned at the thin end. The straw is tall, thick, and reedy, and not well adapted for fodder. The Tartarian oat is particularly well suited for marshy or peaty soils, and not unfrequently yields from 80 to 90 bushels per statute acre, where the ground has been *clayed* or *gravelled,* and is otherwise in good condition. It grows well also on high-lying late soils, to which its property of ripening early is well adapted, but as it loves moisture neither a dry climate nor a dry soil is favourable to its growth. The writer has tried the cultivation of Tartarian oats on a dry trap soil, but always with results greatly inferior to those obtained from the white-skinned varieties. It is an excellent oat for feed-

ing horses with, and has been long cultivated in England for that purpose. In Scotland it is often made into meal, the quality of which is very superior, but millers dislike it on account of the husks which, being black, discolour the meal when not completely separated from it. The weight of the grain per bushel ranges from 35 to 40 lb., but the latter weight is not often attained unless on fine, firm, clay loams, situated in a good climate.

Dun Oat.—This sort, as its name imports, is of a dun or dark-grey colour, and appears like a hybrid of the old black variety (not the Tartarian) and some of the white sorts. Cultivation on different soils greatly alters its characteristic colour. On clay, or cold-bottomed soils, it retains its natural colour, but when grown for several years on light dry land, it rapidly becomes white, and greatly deteriorated both in quality and quantity. A clayey or cold soil, therefore, appears to be its proper *habitat,* and there its cultivation is more successfully pursued than that of the white varieties. A kindred variety known as the winter dun oat is so extremely hardy as to be sown extensively in the west and north-west of France as a winter crop (Lawson), and is found to stand the severest frosts remarkably well. It is also cultivated in some parts of Ireland as a winter crop, and as it ripens early and is ready for being cut before any other kind of grain, it is found extremely valuable on account of the scarcity of oatmeal, too frequently experienced in that country towards the end of summer. The common Dun oat is grown extensively in several parts of Scotland, but always as a spring crop; but in the south of England it might succeed as a winter-sown crop. It is very prolific, although it usually stands thin on the ground. The grain is of excellent quality, and yields remarkably well in meal, which is of very superior quality, possessing the same *flinty* texture as that of the common and Tartarian varieties. This oat is highly deserving of the attention of farmers who cultivate cold-bottomed soils.

Of the 54 varieties of oats described in ‘Lawson's Agriculturist's Manual’ and ‘Supplements,’ those mentioned in this article are by far the most valuable to the farmer. The writer of these remarks dibbled 23 varieties of oats in small lots after lea in the spring of 1848, on a piece of good black land, and the results were very decidedly in favour of those already described. The best crops were obtained from the Sandy Potato and Hopetoun among the earlier varieties, and from the "Late Angus" among the common oats. The Sandy and late Angus gave the greatest bulk, and the straw of both stood remarkably well, although nearly 6 feet long. The latter was 10 days later of being reaped than the former, and even then it was scarcely ripe. Had it been allowed to ripen fully the difference would have been

from 15 to 18 days later than the Sandy. It may be mentioned here, that although these experimental oats were sown with little more than 3 pecks to the acre, the crop was fully better than that sown broadcast alongside with 4 bushels to the acre.

Having made some remarks on the physical conditions necessary to the growth of oats under the varying circumstances of soil and climate, and given a description of the more important varieties of this grain at present under cultivation, we will now proceed to the consideration of the proposition, "Whether the effect of the cooler climate of Scotland can be compensated in the southern parts of the island by an improvement of cultivation?" We have already attempted to show that, in a general point of view, soil has less influence on the growth of the oat plant than climate; and that were the sandy plains of Norfolk, or the chalk downs of Surrey or Wiltshire, transferred to the cooler climate of Scotland, their capability to grow oats would be greatly increased. At first sight this would appear to settle the point, for as we can exercise little influence over climate, the conclusion forced upon us would be one totally opposed to the practice of sowing oats in the south of England, especially on the drier soils. There are other considerations, however, which, when taken into account, will be found greatly to modify this conclusion. These refer to the treatment of the soil—selection of varieties of oats specially adapted to soil and climate—change of seed, and period of sowing—all of which exercise more or less influence in modifying and altering the natural effects of climate.

In Scotland both the quality and quantity of oats have been greatly improved and increased within the present century, and these results have been obtained by more cleanly cultivation, a better system of cropping, attention to the quality and kind of seed sown, and a regular practice of changing it from a good soil and climate to localities less favourably situated in these respects. The Scotch farmer knows that a dropping cool summer will produce a heavy crop of early oats, but that a drier or hotter one will give a better one of Late or Common oats, which are two to three weeks longer of coming to maturity. Apply this fact to the case of south England, and what do we find? Why, that there the summers are nearly always what would be termed *dry* in Scotland. The harvest there is also about a month earlier, consequently the later varieties of oats, which require more sun to ripen them than the earlier sorts, should be sown. Again, the spring and summer climate of south England is about four or five weeks in advance of that of the northern part of the island. Thus the mean maximum temperature of February at Thwaite, in Sussex, corresponds nearly to that of March at Dunino, in Fifeshire, and of Edinburgh, in Mid-Lothian; and so on in succession with the

other months up to harvest. The greatest difference occurs in the mean maximum temperature of July at Thwaite, as compared with that of August at Dunino—the former being 71° 9′ Fahr., and the latter 64° 9′. The hot months of June and July in south England are very inimical to the gradual ripening of oats, and to obviate this they should be sown early, in order that the plants may be in ear before the hot weather is far advanced. The oat seed-time in Scotland extends from the 10th of March to the 10th of April, according to circumstances. In south England oats should be sown early in February, and even sooner if the variety to be cultivated belong to the later sorts. By early sowing the young plants are up and covering the ground before the hot season arrives, and the natural moisture is thus economised and preserved from evaporation.

The time that elapses from the period of oats coming into ear and complete ripening is much shorter in England than in Scotland. In the latter it extended to 60 and in some cases to 70 days in the moist summer of 1848, but in drier years it is about 10 days shorter than this. It is a common saying that it is "six weeks from *earing* to *shearing*" (reaping), but this is undoubtedly more applicable to south England than to Scotland generally, where the usual period is from seven to eight weeks.

Another important point of inquiry is the variety of oats that should be sown. In the southern part of the island, where this grain is principally used for feeding horses and fattening stock, the main object hitherto seems to have been to obtain as much bulk of straw and as many bushels per acre as possible, without much regard to the quality of either; and hence we find the coarser varieties—such as the "Tartarian" and Red sorts—principally cultivated. The straw of these coarse kinds makes very inferior fodder, and the grain weighs very light in the bushel—more frequently 35 lb. per bushel than above it—in consequence of the large proportion of husk it contains. In Scotland, and the north of England, the quality of both straw and grain is a material point, as the former constitutes the principal fodder of live stock from Martinmas to Whitsuntide, while the latter made into meal is—notwithstanding Dr. Johnson's contemptuous opinion of it—the main article of food of the Scotch and Border peasantry. The Scotch farmer, therefore, cultivates those varieties of oats which yield the greatest amount of nourishment for man and beast, and not those that afford the largest quantity of materials for swelling up the bulk of the manure heap. This opposite practice accounts for the fact that the produce of oats per acre in some of the English counties far exceeds what is obtained in Scotland, so much so, that it is a matter of astonishment to hear of 14 qrs. per acre of Black or Red oats, and this we believe to have been obtained on

some parts of the Fens. It may be well to inquire here if these large crops of coarse and light oats be really more profitable than a smaller yield of a finer and heavier variety.*

The grain of oats consists of two easily separable parts—the husk or envelope, and the kernel or *groat* as it is sometimes called. The former is hard and woody, and contains little or no saccharine, oily, or azotised matter. The kernel, on the contrary, is rich in all these substances, hence the larger it is in proportion to the husk the greater the feeding properties of the grain. In a good season for oats, some varieties, such as Potato, Sandy, Dun, and Late Angus, weighing 42 lbs. per bushel, will yield 209 lbs. of meal per quarter, or 62 per cent.; while a coarser and more husky variety, such as the Tartarian and Red oat, which only weigh 35 lbs. to the bushel, will not yield more than 130 or at most 140 lbs. to the quarter. This is only on an average about 48 lbs. of meal from 100 lbs. of grain, or nearly a fourth less than in the other case. If we suppose—which is not far from the truth—that the comparative yield per acre of a fine and a coarse variety of oats, sown on the same quality of land, is 8 and 10 quarters respectively; then, according to the above data, we obtain the following result:—8 quarters of oats weighing 42 lbs. per bushel give 2688 lbs. of grain, which yield 1672 lbs. of oatmeal; 10 quarters of coarse oats, weighing 35 lbs. per bushel, give 2800 lbs., which yield 1350 lbs. of oatmeal. Here we have in the smaller crop nearly one-fifth more meal, and besides the straw is excellent fodder, while that of the coarser kind is fit only for litter. No doubt the finer sorts of oats, when cultivated in the south of England, will not weigh more than 40 lbs. per bushel, but this weight could easily be attained by good cultivation, careful selection of seed, and occasionally changing it from a good oat-growing district. Taking the latter weight, and comparing it with the foregoing numbers, we have the following result:—8 quarters per acre of oats, 40 lbs. per bushel, weigh 2560 lbs., yield 1496 lbs. of meal. This is still a larger quantity of nutritive matter than what could be obtained from 10 quarters of coarse oats, weighing only 35 lbs. per bushel. The above quantities of oats could only be obtained from good land in high condition, but this does not affect the argument, inasmuch as the relative quantities of fine and coarse oats obtained from a given space of ground will generally be in the proportions stated. It

* For the feed of horses, sheep, and stock generally we consider the White Tartarian variety much preferable to the Potato, as they will on poor soils, as a fallow crop, yield from eight to ten quarters per statute acre, weighing (if sown early) from 38 lbs. to 40 lbs. per bushel. The Potato oat (seed direct from Scotland) has been tried in Bedfordshire by the writer of this note, and found to deteriorate so greatly in quality that it has been very unproductive on poor land.—S. Bennett.

may, therefore, be worthy of experiment for the south England farmer—especially on fine land—to sow one or other of the finer sorts of oats, such as the Sandy, or *late* white varieties, instead of the coarser sorts.

Another important element in the cultivation of oats in a dry, warm climate is the quantity of seed that should be sown per acre. It is a pretty generally acknowledged fact that a much smaller quantity of seed is required in a dry climate than in a moist one. A thin sown crop will resist more drought than a thicker one, simply because the roots of the plants being fewer, are stronger and strike deeper into the moist subsoil. The common occurrence of a thickly sown crop turning yellow by continued drought, while the thinner seeded one retained its green hue under the same circumstances, cannot have escaped the notice of even the most unobservant, and certainly if the growing of oats in the dry climate of South England is ever to equal that of the moister, cooler, and in this respect, more highly favoured districts to the north of the Tweed, thin and early sowing must be adopted.

General Management.—The established order of succession in nearly every good rotation of crops, places oats after grass either depastured or cut for hay. Throughout Scotland this rule is nearly absolute, although there are some cases afterwards to be mentioned where oats follow green crops. When sown after grass there are several modes of managing the land. If it has lain *one* year and been depastured by sheep, it is considered to be in as good order for producing a crop of oats as if it had been grazed *two* years by cattle, owing to the more equal distribution of the manure over the surface by the former. On first class soils excellent crops of oats can be grown, after clover and rye-grass, either cut for hay or soiling. On secondary soils something more is required in order to obtain similar results, consequently the practice of all good farmers is to pasture at least one year with sheep or two years with cattle before breaking up the field for oats, and if the grass has been cut for hay the aftermath should be depastured, and during the following winter the whole surface regularly folded over by sheep eating turnips, and cake or grain. In this case 1 acre of turnips (say 20 tons) will go over 3 acres of lea, and the dung made from their consumption by sheep will produce as good a crop of oats as one year's pasture by sheep, or two years by cattle. On inferior soils the grass should always remain two or three years in pasture, and this will be found the most profitable plan of managing them. The following crop of oats has every chance to be a good one when this plan is pursued, and all the other crops during the rotation will be benefited by having a store of slowly decompos-

ing vegetable matter to feed upon. When land has lain more than four years in grass it is found necessary, when it is broken up, to take two crops of oats in succession in order that the sods may be properly decomposed before sowing a green crop. This does very well on good land, and the second crop of oats is generally the best of the two, but on inferior soils it should be avoided if possible, as it is a quick method of carrying off all the ready, soluble matter. The sods, or undecomposed turf, can easily be got rid of by putting them into the bottom of the drills when preparing the ground for sowing turnips or planting potatoes, and then covering them up along with the manure. No better crops of turnips or potatoes can be grown on such land by any other mode than is obtained by this simple one of disposing of the undecomposed sods, and thus converting them into manure under the plants they are intended to nourish.

The ploughing of lea ground intended to be sown to oats is seldom commenced in Scotland before New Year, and generally very little is done until February owing to the prevalence of frost and snow in January. The usual and proper plan is to commence ploughing the older leas first in order to give time for the tough sod to decompose before seed-time. The clover-stubbles are left last, as they are always freer, and require less time to become mellow. In South England where there is little frost, comparatively speaking, to disintegrate and mellow the soil, the ploughing of lea ground should be commenced and finished much earlier than in Scotland; and probably it would be found advantageous to *rib* or half-plough the land across in autumn, harrow it down in January, and clean-plough and sow immediately afterwards. By this method the active soil would be dry all winter, the vegetable matter well decomposed before seed-time, and the ground easily reduced to a proper state either for the seed being drilled or sown broadcast.

In ploughing lea-ground for oats it is a good plan to use the *press* or drill roller in addition, especially on light or soft soils. The sod or grassy part of the furrow-slice is pressed down and completely buried by this machine, while the tapered periphery of its wheels forms a solid and regular bed for the seed, less of which is required owing to the complete manner in which it falls into the hollow parts—even when sown broadcast. It is also generally thought that neither the slug nor wireworm is so destructive to the young plants on press-rolled land as where it has been ploughed in the ordinary way. The writer uses a press-roller for pressing land for wheat, which has a sowing apparatus attached. The *presser*, drawn by two horses, goes behind two, three, or more ploughs as may be required, the wheels form the seed-bed, and the sowing apparatus driven from the same axle, deposits the

seed which is covered by a small harrow hooked on behind. In preparing lea ground for oats the sowing apparatus could not be used when the ploughing is done in winter; but for land after green crop or after lea that has been rib-ploughed early in winter and again to be ploughed in spring, the several processes of ploughing, pressing, sowing, and harrowing can all be accomplished at one operation. The press-roller is remarkably well adapted to the preparation of dry, light land for sowing grain of any description, but on damp or clayey soils it is not so useful, neither does it work so well owing to the greater liability of the wheels to become clogged with earth.* The addition of a sowing apparatus to the common press-roller has not, so far as the writer is aware, been tried before, and the one mentioned above is solely his own invention, and consequently the remarks referring to its usefulness are only entitled to such an amount of confidence as the testimony of one individual can afford.

The ploughing of lea-ground is one of the nicest operations the ploughman has to perform, as any deviation from a straight line in the furrows is easily seen, and is always particularly offensive to the eye of a practical farmer. In Scotland the land is ploughed in ridges (Anglicè stetches), generally either 6 or twelve yards wide, or in broad *feirings* of various dimensions. Clay land, or low lying damp land of any kind, is usually laid in 6-yard ridges, but by far the most common size on ordinary, well-drained soils, is the 12-yard ridge. On thin, dry land, where open furrows are not only useless but in some degree hurtful, owing to the greater exposure to drought, wide *feirings* are preferred. When the ridges are long and the field large the usual plan is to lay two 12-yard ridges together, by *hupping,* or turning to the right hand at the ends, and when this has been accomplished, to plough three 12-yard ridges by *winding,* or turning to the left hand. But before commencing to plough the field, it is marked off in parallel *breaks* 60 yards broad, or in every fifth open furrow if the land has been laid down in 12-yard ridges. It will be seen from this arrangement that, by laying two ridges (24 yards) together at each of these, marking and *winding* out the intermediate spaces, there will only be one open furrow every 60 yards. In smaller fields, with shorter ridges, ploughing in large *feirings* causes a great deal of lost time in going so great distances along the ends, it is better therefore to lay two ridges together at the *markings* as before, and only to leave one between them instead of three. There will thus be an open furrow every 36 yards, and to guide the sower, when sowing broadcast, a

* The system alluded to, of a sowing-machine being fixed and worked by the axle of the press roller, has been adopted by me for at least ten years with great success.—S. Bennett.

slighter furrow than common is made every 6 yards. A 6-yard ridge should contain 24 furrows, each 9 inches broad, and in order to have them all lying at 45°, the proper angle of inclination, the depth should be rather more than 6 inches—by mathematical calculation 6·3639 inches. In ploughing lea either in 6 or 12-yard ridges, the last fast furrow of each ridge should be turned over by a plough drawn by one horse, or if necessary two horses, walking in the open furrow; because when two horses walk abreast in performing this operation, the one on the left side of the ploughman must walk on the ploughed land, which if wet or clayey, will be more or less poached in consequence. On dry light land this is of little consequence. Lea ground should never be ploughed when the furrows are so wet as to become *glazed* by the action of the mouldboard, unless it be very early in winter and in a locality where there is usually plenty of frost to counteract the bad effects of wet ploughing. To plough too wet in spring is sure to produce a hardened furrow on the first appearance of drought, which never breaks down kindly however much it may be harrowed.

Sowing and Harrowing.—The general practice in Scotland is to sow oats broadcast on the winter furrow, and to cover in the seed by two, three, or four harrows coupled together, and drawn by as many horses. On clay farms, where the ridges are narrow, two harrows, drawn by two horses, are generally used, but on dry land farms three or four harrows are generally employed, one horse to each, and the whole driven by one man. In sowing oats broadcast an active man can easily get over 25 acres of level land in a day, and on hilly ground about 5 acres less. Six harrows, three and three together, drawn by six horses and driven by two men, follow the sower and give a double *stroke* in the direction of the ridges. The next double stroke is either given across the field or obliquely, and if the land is moderately friable, another single stroke in the same direction as at first will generally be sufficient to finish the operation of harrowing. Old, tough lea, or wet ploughed land requires a far greater amount of harrowing than this to bring it into a proper tilth. Two double strokes are given in the direction of the ridges to break the furrows and prevent the turf from being torn up by the cross harrowing, and it is seldom that the operation can be properly accomplished with less than six double *strokes* or twelve harrowings. The previous use of a heavy press-roller greatly facilitates the operation of harrowing, and renders it also more effective. When the harrowing of the seed has been accomplished, the open furrows should be cleaned out with a double-moulded plough, and water-furrows cut across the lower end ridge, and also any part of the field where water is apt to stagnate. It is not usual to roll oats unless the

ground is very light, but if so it is always rolled when the weather becomes droughty.

The quantity of seed sown per statute acre in Scotland varies from $3\frac{1}{2}$ to $5\frac{1}{2}$ bushels. The early and small seeded oats, such as the Potato and Sandy, are always sown thinner by about $1\frac{1}{2}$ bushels to the acre than the coarser-grained sorts, such as the Late Angus and Tartarian varieties. The error of the Scotch farmer hitherto has been to use considerably more seed than what is necessary. The moistness of the climate has greatly favoured the practice, and counteracted its bad effects by keeping these thickly-sown crops in a healthy growing state; but in a drier climate the same error would occasion much more mischief, inasmuch as the thicker a crop is sown the more does it suffer ultimately from long-continued drought. Three bushels of early and small-seeded oats are quite sufficient to sow an imperial acre with, and 4 bushels of the coarser-grained sorts.

When oats are sown after pasture, or sheep folded lea, they seldom receive or require any manure, but after hay the crop is greatly benefited by 2 or 3 cwt. of guano harrowed in along with the seed. The increased quantity of straw obtained will, from its valuable forage qualities, nearly repay the cost of the guano, while the proportionate increase of grain will yield a profit besides. In dropping summers the action of guano on the oat-crop is very marked, in dry years less so; but in almost every instance it will pay itself, and something more, provided the error of too thick sowing be not committed. It is the tendency of guano, when sown along with oats, to produce a strong, thick, powerfully tillering plant, but if too much seed be used the plants will become over crowded, and if a track of dry weather set in about the time of earing, the crop will fall off rapidly in bulk, and cut a very sorry figure at harvest. The application of guano to the oat-crop in south England, therefore, should always be accompanied by early and thin sowing, in order that the plants may strike their roots deep into the ground, and be supplied with moisture even when dry weather prevails.*

The foregoing remarks, in this section, on the sowing of oats

* Mr. Gardiner of Barochan, who has been a most indefatigable labourer in the field of experimental inquiry, published in the 'Transactions of the Highland Society of Scotland' the results of a series of experiments with special manures on the growth of oats, from which it appears that 1 cwt. of Peruvian guano, 2 cwt. of common salt, 1 cwt. of animal charcoal, and $\frac{1}{2}$ cwt. of sulphate of magnesia (Epsom salts), costing in all only 19*s*. 6*d*., produced per acre within a peck of 20 bushels more than that portion where no manure had been applied. The quantities of oats yielded per acre were 8 qrs. 6 bush. 3 pecks, and 6 qrs. 3 bush. respectively. In another instance, on moss-land, a mixture of 1 cwt. Peruvian guano, 1 cwt. animal charcoal dissolved in $\frac{1}{2}$ cwt. of sulphuric acid, 1 cwt. common salt, 1 cwt. of silicate of soda, and 1 cwt. of horn-dust, costing in all 1*l*. 14*s*. 1*d*., gave an increase of nearly 24 bushels of grain, the relative quantities being 8 qrs. 6 bush. 3 pecks where the manures were applied, and only 5 qrs. 7 bush. on the portion not manured. The *silicates* are highly useful on soft soils, in giving greater firmness to the culms of oats.

after lea, apply in a great measure to the oat-growing districts of England and Scotland, but with regard to the south and south-eastern counties of England I have considerable hesitation in expressing an opinion as to the propriety or impropriety of abandoning the present practice there of sowing wheat after lea, and of substituting oats in its stead. In the Norfolk system oats are inadmissible unless substituted for barley, and neither are we prepared to advise this; but were it considered desirable to alter this system, in order to lengthen out the period between one crop of clover, or turnips, and another, oats might be introduced as the means of doing so. Thus the Norfolk course, consisting of clover, wheat, turnips, barley, might, on good soils, give place to clover, wheat, beans, oats, turnips, barley, or on light soils to grass pastured two years, wheat, peas, oats, turnips, barley. In the first of these rotations the acreage amount of clover and turnips would be diminished, but the produce per acre would be increased in consequence of the same crops only recurring every sixth, instead of every fourth year. The six-course rotation in Scotland is different from this, the succession being grass, oats, beans and potatoes, wheat, turnips, barley with seeds, or on some fine soils, grass, oats, potatoes, wheat, beans, barley. On good clay soils oats might very properly follow clover, and wheat be sown after beans, but it is doubtful if the Norfolk farmer, occupying a turnip soil, will ever be induced to allow oats to take the place of wheat.

On soft alluvial or gross soils, where barley cannot be grown with profit, even in a dry climate, and wheat only at lengthened intervals, the cultivation of oats becomes essential to an alternate system of cropping. We have the choice either of taking grass, oats, turnips, wheat, or of grass, wheat, turnips, oats. The individual crops are the same in both cases, but the practical points connected with them are somewhat different. Thus wheat can be sown under much more favourable circumstances after grass than after turnips, and from getting it earlier sown the quality of the grain will be greatly superior also. In Scotland, Ireland, and the north of England, it is doubtful if wheat should ever be made systematically to assume the place of oats, because, under ordinary circumstances, as profitable crops of the latter can be obtained without manure as of the former with it—which is exactly the reverse of what happens in the southern part of the island, where wheat can be grown with less expense than oats. The subject thus resolves itself into the two following propositions:—First, oats can only be cultivated successfully in south England at a greater expenditure of labour and manure than what is required in Scotland; and, secondly, they can never be substituted profitably for wheat or barley on light soils situated in a dry and hot climate, at least as long as the present relative prices of grain continue.

Harvesting the Oat Crop.—All the earlier varieties of oats should be cut *raw*, as they are apt to shed their seeds when allowed to ripen completely. The sandy oat is, perhaps, the only sort that may be allowed to stand until the straw is uniformly yellow, without incurring loss from the grain shedding out, either by a moderate breeze of wind or by the operation of reaping. Late or common oats are less liable to shake when ripe; and the straw, even although entirely deprived of its green colour, still retains a considerable amount of sap, a circumstance which may account in some degree for its superior forage qualities. The straw of early oats, on the contrary, when quite ripe, is sapless and brittle, and, unless cut a little green, makes very indifferent fodder. In neither case, however, is it advantageous to permit any kind of oats to become *dead* ripe before commencing to reap; for although cut ten days before this, the ripening process will proceed perfectly well in the sheaf, and certainly with much less risk. The writer's experience has for many years been in favour of cutting all the early sorts of oats when the green and yellow colours were about equally mixed; and in every instance where this has been practised, the result as to quality and quantity, both of the grain and straw, has been perfectly satisfactory.*

When oats are cut with the scythe, the operation should be performed by cutting *up* to the standing corn, as there is less risk of rippling and shaking out the grain than when cutting *away* from it. In Scotland the hook is generally preferred to the scythe for reaping oats; for the crop is generally so heavy and laid, and otherwise twisted together, that the scythe at the best would make but miserable work. Six reapers and one bandster complete what is termed a *band-win;* and they will cut down two acres of good oats in a day. In some districts of Scotland the reapers are paid 3*d.* per *threve,* of 24 sheaves each, 12 inches in diameter. The bandster receives from 10*s.* to 11*s.* a week, with victuals; and he is generally hired for a month. An acre of good oats generally averages about 32 *threves* (768 sheaves), which, at 3*d.* per threve, costs 8*s.* for reaping; and if we add 2*s.*

* An amusing instance of the prejudice which some farmers have against cutting grain before it is perfectly ripe occurred in reference to myself in the harvest of 1848. I had begun my harvest before any of my neighbours; and one of them, coming into a field of rather unripe looking potato-oats in course of being cut down, sarcastically remarked, "Well, after *that* we need not care when we begin our harvest." Another farmer, some time after, remarked to a miller, that "Mr. ——— was cutting his oats quite green, and quite unfit for being reaped." The miller asked him to step into his premises, and he would show him a parcel of *new* oats he had just received. After examining them, the farmer admitted they were certainly as fine oats as he had ever seen. "Well," replied the miller, "these are Mr. ——'s oats that you and others have been ridiculing him for cutting so soon." The oats were 43 lbs. per bushel; and although threshed out of the field yielded 18½ Scotch pecks of oatmeal to six bushels. This is at the rate of 216 lbs. of oatmeal to the quarter of oats.

for binding and superintendence, the whole expense will be 10*s.* per acre, for cutting oats in this way. In other districts it is customary to get the crop reaped for so much per acre; 10*s.* to 10*s.* 6*d.* per acre for wheat, oats, and barley, is about the usual price given. In other parts the reapers are either hired for the whole harvest or from day to day, or week to week. The writer has never tried any other than the first of these methods, and may therefore be prejudiced in its favour; but with an active, firm-minded overseer it is as cheap as the others, and much less troublesome, as the reapers provide their own victuals.

When oats are reaped with the hook they are always set up in shocks of 12 sheaves each, two shocks making a *threve.* The general custom in late districts is to put two sheaves, butt to butt, on the top of each shock. In early districts these hood-sheaves are frequently dispensed with; for although they keep out rain, they also keep out wind, and prevent the other sheaves from drying so quickly as they otherwise would. Oats generally take from a fortnight to three weeks to be ready for carrying to the stack-yard; but this varies greatly with the weather. They should never be carried so damp as to cause heating, as this greatly injures the colour of the grain, and renders the straw worthless for fodder. Corn stacks are always made round in Scotland, both for conveniency and ventilation. Oat stacks are generally made to hold from 120 to 200 shocks, according to the size of the farm; and it is a common practice to place a three-legged vent inside, to promote a freer circulation of air through them. They are thatched with wheat or barley straw, which is tied down with ropes made of tough oat straw. The thatching will cost little more than ½*d.* per quarter; and this includes the making of the ropes also.

The cost of cultivating an acre of oats on a light trap (whinstone) soil, with which the writer is personally acquainted, together with rent and taxes, in 1848, is nearly as follows:—

Ploughing lea, one furrow, 9 to 10 inches broad	£0	7	6
Sowing broadcast (one man, 2*s.*, and one woman, 8*d.* per day, 20 acres)	0	0	1½
Seed, 3½ bushels, at 2*s.* 6*d.*	0	8	9
Harrowing 2½ double strokes (five times), six horses and two men finish 10 acres	0	2	6
Handweeding, twice	0	0	9
Reaping 64 shocks, 12 sheaves, each 1½*d.*	0	8	0
Binding, setting up, and superintendence	0	2	0
Carrying and stacking 10 acres per day, 1 builder, 1 forker, 3 carters, and 3 double-horse carts; the men at 2*s.* 6*d.*, and the horses 2*s.* 6*d.* each per day, cost per acre	0	2	9
Thatching	0	0	6
Threshing 48 bushels by steam	0	1	4
Marketing	0	3	9
Rent and taxes in 1848	1	10	0
	£3	7	11½

The produce was 6 quarters per acre, which, at 20*s.*, gives 6*l.*; thus leaving a balance of 2*l.* 12*s.* 0½*d.* for interest on capital and profit. At the present prices of oats (15*s.* per quarter) the value of produce would only be 4*l.* 10*s.* per acre; but as the rent is partly paid in grain, the charge against it on this head will be about 4*s.* per acre less for crop 1849. Calculating from these data, we have as before:—

For horse and hand labour, cost per acre . . .	£1	8	2½
Seed, 3½ bushels, at 1*s.* 10½*d.* ,, . . .	0	6	6¾
Rent and taxes for crop 1849	1	6	0
	£3	0	9¼

which, deducted from 4*l.* 10*s.*, the value of produce, leaves 1*l.* 9*s.* 2¾*d.* for profit and interest on capital.

When oats in the straw are purchased either on the ground or after being stacked—as is generally done by auction in Scotland—the straw is usually valued at 3*d.* per stone of 14lbs.; and as 8 bushels will yield from 30 to 35 stones of straw, the whole value of the oat-crop (straw and grain), supposing it to be 6 quarters per acre, will be as follows:—

6 quarters of oats at 20*s.* . .	£6	0	0
195 stones of straw, at 3*d.* . .	2	8	9
Total .	£8	8	9

Economical Uses of Oats.—"In England," as Dr. Johnson more wittily than wisely remarks, "oats are food for horses, and in Scotland food for men;" but this is only true as regards the southern part of the island, as oatmeal is largely used in the northern counties of England. In Scotland and Ireland it is (cheap as wheaten bread is at present) still the principal food of the rural population, as well as of that portion of the mechanic class whose employment is not of a sedentary nature. In a warm climate, oatmeal is not an agreeable nor healthful article of human diet, as it heats the blood and produces eruptions on the skin; neither is it a proper food for persons engaged in sedentary employments; but for all who are exposed to plenty of outdoor exercise or labour, in a bracing atmosphere, no species of food can be more wholesome or nutritious. Professor Johnston, of Edinburgh, has rescued this excellent article of diet from much unmerited obloquy, by showing that the grain from which it is made is rich in those protein compounds which constitute the *muscle*-forming principle of the animal frame. In some of the eastern counties of Scotland the unmarried ploughmen live solely on oatmeal and milk, except in winter, when they get potatoes in addition; but the latter is generally optional on the part of the employer, and is often discontinued when they become high

priced. The regular allowance to each man is 65 stones of oatmeal per annum, or $17\frac{1}{2}$ lbs. weekly, with 12 gills of new milk daily; and on this diet, with no other cooking than boiling water stirred among the meal, the ploughmen are strong and healthy. The writer does not advocate this system of dieting ploughmen; and he only adduces it in proof of the nutritious and wholesome nature of oatmeal, as food for people engaged in outdoor labour. Wheaten bread might, no doubt, be introduced with great advantage into the dietary of the Scotch and Irish agricultural labourer; and if the present low price of wheat continue, there is every reason to expect that its use will soon become more general, at least in the former country; but before it can be made entirely to supersede that of oatmeal, the tastes of the people must undergo a great change. Whether right or wrong, a Scotch labourer never thinks he can stand so much fatigue on a wheaten flour diet as on one of oatmeal; and so long as he thinks so he will retain his preference for the latter.

The making of oatmeal forms a source of considerable employment to a great many people in Scotland. The millers purchase oats from the farmers, make them into meal, and sell the produce principally in villages and manufacturing towns. The husks of the grain are used for mixing with whole oats, for feeding horses, and with crushed grain or oilcake for cattle. Large quantities of husks — oatmeal *seeds* they are commonly called—are also disposed of to distillers, who mix them with their spent grains, and sell the mixture for fattening cattle or sheep. The usual price of oatmeal *seeds* is from 4*d.* to 6*d.* per four bushels, the weight being about 12 lbs. per bushel.

When farmers get oats made into meal for the use of their families and servants, the miller retains as *multure* $8\frac{3}{4}$ lbs. (a Scotch peck) for every boll (140 lbs.) of meal produced.* The proportion of meal, husk, and moisture of potato oats (41 lbs. per bushel) of crop 1849, grown by the writer, was in 100 parts as follows:—

Meal . . .	57·34
Husk . . .	22·64
Waste in drying (water)	20·02
Total .	100·

One quarter of these oats, weighing 328 lbs., would thus yield—

	lbs.
Meal . . .	188·08
Husks . . .	74·26
Water . . .	65·66
Total .	328·

* In those districts where *thirlage* does not exist or is falling into disuse, the charge for grinding is generally commuted into money, one shilling being charged, instead of a peck of meal, for every six bushels.

The proportion of meal here stated is rather below than above the average for oats of this weight, and may be accounted for by the fact that the crop ripened prematurely, owing to the dry nature of the soil, combined with long-continued drought, during the latter part of last summer. The quantity of oats employed in obtaining the above results was 11 quarters, which were dried in the ordinary way on the kiln; the principal object in view being to determine the quantity of moisture driven off by heat.

In conclusion, it may be stated that oats are generally allowed to be by far the most wholesome food for horses, and consequently their consumption is very large throughout the British islands for this purpose. Beans, linseed, and barley, are excellent auxiliaries; but if we consult the taste and health of our horses, oats must still continue to be their principal food. In those districts where oats are extensively grown, the light or *tail* corn goes a considerable length in feeding the horses upon a farm; and where this is the case, the expense of horses' food is little felt, as this inferior grain would fetch but a low price if taken to market.

VI.—*Experiment and Experience in the Growth of Wheat, year after year, on the same acre of land.* By the Rev. S. Smith.

Last October I took in hand a measured field of four acres, in order to carry out, more extensively, my experiment in growing wheat.

I ploughed the short stubble—for the field had just been in wheat—an inch deeper than the used staple; cleaned and levelled it; and got in my seed in channels made by the presser, covering over with the crusher.

The following sketch gives a view of the growing plant; the spaces *in* each triple row being one foot, and the intervals *between* each triple row, three feet.

In this stage of growth, at the beginning of November, when the triple rows of wheat were distinctly visible, I trenched the intervals for the succeeding crop, bringing up six inches of the subsoil to the surface, and casting the seven ploughed inches of staple to the bottom. In the spring I well hoed and hand-weeded the rows of wheat, and stirred the intervals with a one-horse scarifier three or four times, up to the very period of flowering in June.

What has been the result?—The field I am describing is a gravelly loam, with a varied subsoil of gravel, clay, and marl. It has been hard worked, for nearly a century at least, by tenant after tenant; has never known a bare fallow in the memory of man; and my operations followed immediately after a heavy crop of wheat sown broadcast. I applied no manure; and, having dropped single grains about three inches apart into the pressed channels, I sowed but little more than a peck of seed to the acre. And, what has been the result?—During winter, and up to April, the plant looked so thin and so very far between, as almost to excite ridicule. The wheat, however, began then to mat and to tiller. May came; and all through that trying month it kept its colour, without a tinge of yellow. And now the well tilled intervals have told upon the grain, which has swollen to a great size. The compact ears are enormously heavy and large. The reed-like straw has borne up against the storms. And there, at this moment, as level and as laughing as the slightly rippled sea, stands as fine a crop of wheat as ever I beheld, promising from the half portion of each acre a yield of from 36 to 40 bushels.

I expect a similar crop, year after year, on the same four acres of land, treated in the same way. I do so, because experience justifies my expectation, and, as I conceive, science confirms it.

First, as to experience. To those who are acquainted with the history of British agriculture I need scarcely say that, while in practice I differ wholly from Jethro Tull in the management of wheat, the leading principles by which I am guided are his. And Jethro Tull, whose veracity was never doubted, asserts boldly, that "the more successive crops are planted in wide intervals, and often hoed, the better the ground does maintain them. The last crop is still the best, without dung or changing the sort of plant." "My field, whereon is now the 13th crop of wheat, is likely to be very good;" the crop before it having been "the best that ever grew on it." And, to make the statement more remarkable, he adds in a note, "I am sorry that this farm, whereon only I have practised horse-hoeing, being situate upon a hill that consists of chalk on one side and heath ground on the other, has usually been noted for the poorest and shallowest soil in the neighbourhood."

My own experience, which I will briefly relate, is this. Seven years ago I broke up a few acres of pasture, having breast-

ploughed the turf, and taken it off. Setting apart a portion of this land for my purpose, I devoted the first year to oats, the second to vetches, and the third year to my first crop of wheat on the plan of three feet intervals and double-digging. I have now the fifth crop on the same acre of unmanured land, promising at least, from the half portion of the acre, the customary yield of 34 bushels; many place it as high as 40.* The staple of this land was about five or six inches, with a subsoil of yellow clay, generally very tenacious, but here and there inclining to marl and sand. The stratum is oolitic,—a formation of great extent, running across the country from Melcombe Regis nearly to Whitby.

But I look still more confidently for success to the discoveries and assurances of science. From science we learn that the wheat plant requires a sufficiency of organic and inorganic food to bring it to perfection. And here I beg permission to refer to the experiments at Rothampsted. A certain portion of land has there been exhausted for the purpose, and wheat has been grown on it in the usual mode of cultivation, year after year; the natural produce of the soil per acre being found to be 17 bushels. Now, it is the object of agriculture, says Mr. Lawes, "to increase the produce of the soil beyond its natural yield, which can be done by various means." He then describes these means; one of which is, by fallowing. "The field may be fallowed; that is, the natural produce of the soil for two years may be concentrated into one,—the repeated exposure of the soil to the atmosphere, by means of ploughing, causing a decomposition of mineral matter, while the ammonia in the rain unites with the various acids in the soil."

By the method of tillage which I advocate, this condition is fulfilled. I have the advantage of a fallow year after year, though on the same acre of land, I have, year after year, a growing crop. And what has been the result? I have shown that I concentrate the natural yield of two years into one, and raise the produce from 17 bushels to 34.

Without laying too much stress, however, upon the minute calculations of this interesting experiment of Mr. Lawes, I take it as far as it goes in confirmation of my scheme. Thus much is certain,—that the atmosphere contains every organic constituent of wheat, in the forms of ammonia, carbonic acid, and water. The question is only one of sufficiency. Of carbonic acid there is abundance. And when we look at the ascertained amount of ammonia brought down on the soil by rain, and add to it the occasional supply from the snow, and its unceasing descent with the dew, we need not, I conceive, be alarmed on that score. On certain conditions:—Let the land become crusted over, and its pores closed; let it be only scratched on the surface, and remain

* The 4 acres crop has now been threshed out and has given $20\frac{1}{2}$ quarters of good clean wheat, weight 61 lbs. per bushel, with 8 tons of straw.—S. Smith, Aug. 27.

hardened below; and then the treasures of heaven will still, indeed, fall on its lap, to be carried off again by the parching winds and the scorching sun;—but, open the bosom of the earth for their reception, and richness and fertility will follow.

It is for this reason I look upon the plan of intervals as so important. They are, indeed, my mainstay,—the very support, nay, the building up of my system. For, by the frosts of winter, first of all, then by the dry winds and showers of spring, and afterwards by frequent stirring, they become so pulverized and porous, that the organic elements of fertility contained in the atmosphere gain easy admittance, and are there retained; a small portion for the benefit of the searching rootlets of the growing plant, the larger supply for the future crop.

I dare not, with certainty, claim the free nitrogen of the air as my helper in the process of fertilization, though thus much has been proved:—Under ordinary circumstances, gaseous nitrogen has shown but little tendency to combine with other bodies; but, on trial, nitrogen mixed with excess of hydrogen and burned at a jet, produced water and nitric acid. On another trial, pure nitrogen passed over a mixture of charcoal powder and carbonate of potass, produced potassium in quantity. Future trials may produce further discoveries. "And surely," says Dr. Fownes,* "the chemical energies at work in a living plant are, to say the least, equal in power to those which we have under our control in the laboratory." And certainly, I may add, where the state of the soil affords an easy access to the roots of the plant, the supposition is not groundless, that the free nitrogen of the air *may* take its part in bringing the grain of wheat to perfection.

Then, with regard to the inorganic food required by the wheat. By a gradual exposure of the subsoil in the intervals, I provide a constant supply of this. I have little to contend with here; the question being not so much a question of sufficiency as of expense. For, hear Mr. Way upon this point. "Allowing," he says, "a certain and considerable yearly diminution of the mineral elements of fertility in the land, we have yet, so to speak, an almost infinite supply of these bodies in the soil itself, provided we knew how we might economically avail ourselves of it. This—the item of *expense*—is, after all, the turning point."

Now, let us see what *is* the expense of turning up these treasures with the spade. Let us place the cost of hand-labour against the comparatively ineffectual process of the plough. Say there are three ploughings for wheat, as is the case in this neighbourhood on soil like mine. That, at seven inches deep and 12*s.* the acre, will be 36*s.*; and the time occupied will be three days.†

* Prize Essay "On the Food of Plants," in vol. iv. of this Journal.

† Adjoining my four-acre piece of wheat described at the opening of the paper,

"It will take a good labourer 30 days to trench an acre, and 16 to dig it well," says one high authority. "With proper instruments and some experience, a labourer can dig an acre of light land 18 inches deep in 25 days;" thus speaks another.

Now, at the commencement of my labours in trenching my intervals, I bring up only so much of the subsoil—say four, five, or six inches, according to its nature—as can be penetrated and decomposed by the atmosphere, and so prepared for use by the one year's fallow, increasing the quantity year after year till the staple has become two good spits deep.

Taking, then, the average of these calculations, and commencing with 11 or 12 inches, inclusive of the ploughing the first year, and allowing for obstructions in the variety of soils to be acted on, I will reckon that one man will dig, and in after years by degrees will double dig, an acre in 30 days.

Employing, as I do, six men for my work, I thus accomplish a whole acre in five days, which, at 2*s.* a day each man, amounts to 60*s.*

But only the half portion of the acre is to be dug for one year's crop; and this reduces the time to two days and a half, and the expense to 30*s.*

Say, however, that the charge I have made on ploughing is too high; that the second time of ploughing should be 10*s.*, and the third 8*s.*; and even then, in point of economy, the ploughing and the trenching will be just on a par!

But then *the stones!* The author of 'A short Inquiry into the History of Agriculture' will, I am sure, permit me to take his words and apply them to the spade. "Let me see this instrument in use where there are *no stones*—and there are plenty of broad acres in England of this class—and it will not be long before it gets upon others. If it cost 5*l.* an acre, it must be done, and would in such a case well pay to do it."

There is the possible question still to be answered, "Where are the hands to come from?" With reference to this, let me take a single parish as the average of many. I find, then, that in my parish of 2000 acres there are this year somewhat above 200 acres in wheat; and that, without including the necessary attendants for other purposes on the several farms, we have 50 able-bodied labourers on the spot.

I will here state that, for the better success of my plan, I sow my wheat as early as possible in September.* I do this that it

there is a field of wheat which had four ploughings after beans—had nearly 10 tons of manure from beasts fed on oil-cake—had 3 bushels of seed, and will now yield, it is supposed, *a quarter less to the acre than mine.* It is land of precisely the same quality with mine.

* This is the rule. My process with the present crop was an exception, forced on me by circumstances.

may tiller fully before winter, and so ripen evenly at harvest. Before the end of the month the thin green lines are distinctly visible, and I at once set to work in the intervals.

Now, if it take one man 30 days to trench an acre, it will take 50 men a month and four days to trench 50 acres; and four months and a half to trench 200.

But, only the half portion of these several acres is to be dug; and this will reduce the extent to 100 acres; and the time it will occupy, to two months and eight days. So that, beginning, as I do, the last week in September, I complete my labours the first week in December, *with nearly five months in hand for the casualties of frost, snow, and sickness,* before I am shut out by the growing crop.

Having shown the results of the system of growing wheat which I follow myself, and presume to recommend to others, and having stated my reasons for entertaining hopes of future success to an equal extent, I will conclude with my balance-sheet of expenditure and income. It may be open to objection; but I would point to the wide margin of profits which will still remain after all deductions, where the experience of others does not tally with my own. In fixing the value of the straw at 2*l.* a ton,* I speak, not merely of the price under which I am unable to purchase it myself, but of its intrinsic worth as fodder, litter, and manure. No one who has had his winter beans, as I have them, in single rows five feet apart, and seen them, as I do, covered with large pods from top to bottom, and *meet;* and his swedes, wurzel, and potatoes, at the same distance apart, doing the same, will dispute my valuation of good wheat straw converted into rich forcing manure.

One double-digging in autumn . . .	£. 1	10	0
Three stirrings in the intervals with scarifier	0	3	0
One ditto with scarifier and harrow implement, before sowing	0	1	0
Two pecks of seed (5*s.* the bushel) . .	0	2	6
Pressing and drilling	0	1	0
Rough-rolling	0	0	6
Four hoeings between rows of wheat .	0	2	0
Bird-keeping	0	2	0
All the operations from reaping to marketing	1	2	0
Rates, taxes, and interest	0	10	0
Total amount of outlay . .	3	14	0
Four quarters and 2 bushels of wheat .	8	10	0
One ton 12 cwt. of straw, at 2*l.* a ton .	3	4	0
	11	14	0
Deduct outlay . .	3	14	0
Total amount of profit . .	8	0	0

* I give 40*s.* a ton for it, and cannot get it under that sum. And such is the statement of other purchasers whom I have consulted.

It will thus be seen that, on this plan, with wheat at 40*s.*, the net profits to the proprietor are 8*l.* an acre; to the renting farmer, of course, according to his rent. And it is a plan, I firmly believe, more especially applicable to thousands and thousands of the broad acres spread over England, of hitherto impracticable and unremunerating clay.

One word to those who have entered on the plan, or who purpose doing so. I would guard them against the expectation of receiving the benefit of the scheme without an accurate fulfilment of its conditions. It may be that the directions hitherto have not been precise enough to be an unmistakeable guide to their proceedings. A clear set of instructions will therefore be drawn up for insertion in the forthcoming edition of the "Word in Season; or, How the Corn-grower may *yet* grow rich."

S. SMITH.

Vicarage, Lois Weedon, Towcester,
July 28, 1851.

VII.—*Some Account of the Formation of Hill-side Catch-Meadows on Exmoor.* From ROBERT SMITH, late of Burley.

To Mr. Pusey.

DEAR SIR,—Agreeable with your wish I forward you an outline of the past and future plans laid down for the management of my recently-formed "Catch-Meadows" upon our Exmoor hill sides, alluded to by Mr. Acland, in his Report on the farming of Somerset.

Catch-Meadows form an exceedingly interesting branch of general irrigation, and, from their easy and cheap formation, their extension is now creating a lively interest; still our attachment to early habits and local practices is very great, and can alone be removed by actual experience, or repeated statements of better results.

In changing my residence from the East to the West of England, my attention was naturally directed to the agricultural practices of the neighbourhood, which I found so directly opposed to those of my native county (Lincolnshire), that it became a serious question, which were the better; but on mature reflection I found that it was climate alone which dictated these opposite methods: thus, while our dry districts had their foundation in the growth of corn, the humid districts of the West had their merit in the production of roots and grass, and consequently of stock. Nothing could exceed my admiration of the "water-meadows" in early spring, a period (in the East) when I had been wont to value a blade of green grass as a rare production. To see the Exmoor

ewes with their early lambs (in January) feeding upon the verdant meadow, to me was a miracle;—first, the early period of lambing, and, secondly, the green meadow at such an inclement season. But if we turn to nature as our guide, we find the green grasses ever springing at the water's edge, and yet doubly verdant at the springs, even to the very summit of our forest hills, at an elevation of 1000 feet; thus these practices of agricultural art are dictated to us, and are alone waiting the skill and enterprise of man to cultivate and extend them.

In my early inquiries as to the profitable formation of "Catch-Meadows" on Exmoor, I found much importance attach to the quality of water for irrigation, but accompanied with a doubt as to its varied properties (mineral or otherwise), the general remark being that "warm springs" were found best for irrigation. The undertaking was therefore deferred by me for a time, with a view to some experiments being tried, as it appeared certain that it was next to useless my making even an attempt with the then existing waters, in their impure and boggy state. In the interim all drains, fences, &c., were laid out with a view to subsequent irrigation, and notes taken of passing results.

These experiments went to show, that the waters flowing from the wet peaty hill tops, and joined (or not) in their course by the waters from the uncultivated valleys, were dangerous agents, and from the extent of their course appeared formidable enemies; while in every case where proper drainage had been practised, the water flowed in a pure and healthy state, and at the stream's side were to be seen green and improving grasses. This determined me to take steps for the collection and distribution of these waters upon the forest hillside grasses by means of catch-gutters, with a view to eradicate the moss, and improve them without going through the usual process of cultivation, viz., paring, burning, ploughing, liming, &c., which operations, too, in some cases would be difficult to perform from the declivity of the hill side.

Again, upon a large uncultivated hill farm, that had never been broken up from its original or native state, and waiting for cultivation, it appeared doubly important that the best "table land" should be ploughed first, and an endeavour made to improve the hill sides by water and the washings of manure and soil, that would pass off during the rainy season from these upper arable lands. Before proceeding to the formation of the meadows, a general survey of the whole scheme was effected, the levels taken, and all local difficulties considered. In fact, the whole subject occupied my mind for some few months previously: thus many intricate points were overcome, and new designs suggested themselves. The laying out of a water-meadow is but a secondary consideration, when compared with some general points, such as the certain supply of water, its quality, the facilities of improving it by

artificial agents, its uses in an onward course, the arrangement of sites for cattle-sheds, sheep-yards, water-carriage, fences, &c. If it be desirable that the work should be extensive and the outlay gradual, the work may be extended over a breadth of time, by the general plan being agreed upon, and each succeeding operation steadily and progressively directed to form its part of the intended whole—thus completed as the meadows improve. This is precisely my own case and intention, as a tenant. If the work is executed by the landlord, or wished to be finished at a given time, the better plan is to contract with a suitable party for its certain and effectual completion. The first outlay is the main expense, and is fairly classed under the head of a permanent improvement, the annual expenses to maintain their efficiency being small in comparison with the result.

Catch-meadows (on our hill sides especially) have certainly the advantage of cheapness in their favour, and the same quantity of water will do much more work. The hill side being already formed by nature to our hands, the "spirit level" beautifully traces the varied slopes, and marks the onward course for the "gutterer, or waterman," who should be a man of some taste in the art of levelling, as the marking out the intermediate spaces upon irregular ground is found to be a nice point, that the water may flow in an even stream over the sides of the gutters.

The arrangement of the "main water-carriages" depends solely upon the formation of the land and supply of water; for instance, as I have a small brook passing through the farm (which has a good descent), these carriages take their lead from the stream in due succession, whereby the required supply of water is kept up, and are so arranged that, in crossing the valleys or otherwise, they pass below the hill-side springs, that these may be "tapped" and drained into them; this is a good and cheap process.

These "main carriages" are formed 3 feet wide and 6 inches deep on the lower side, the upper side ranging according to the slope of the hill, and at a distance of 2 chains apart, with a fall of 2 inches upon a chain of 22 yards, or 1 in 396. This is rather a rapid fall for general floating, but it is found desirable to adopt it, to clear out the carriages, after and during the time they are used for washing out soil, &c., to the meadows. Between these a smaller carriage is cut, 18 inches wide and 5 inches deep, at a distance of 3-fifths from the upper carriage and 2-fifths from the lower one. These gutters again collect the water into a sheet, that it may be more evenly spread over the whole surface then under hand; but for this the water gets into little streams, especially where the land has never been ploughed or levelled. This will be further remedied by removing the surplus sods from the carriages to the larger holes, the removal of any banks that may occur, and by the sediment from the watering and soiling as the

work proceeds. This is followed by repeated rollings while the meadows are moderately wet.

The majority of these water-carriages being laid out upon the forest hill side, and the land taken in hand as nature formed it, I find the better plan (to eradicate the moss and encourage the grasses) is to let the water flow over it freely for five or six days in succession, a continued rush of water being certain to effect the desired change, while a thin flow of water has but little effect, and the process of improvement is retarded. The watering is repeated at intervals of a month (more or less), or according to the supply of water; but care is taken not to allow the water to remain too long upon the same place, as by neglect of this kind, coarse and inferior aquatic grasses will spring up, such as are produced near springs that have remained undrained. In the second season, when a certain amount of improvement has taken place, the water may be more thinly spread, and for shorter periods; but local circumstances can alone dictate the working of these details.

Upon steep hill sides that are stony, it is best to make the carriages rather wider and shallower, as the water wastes in passing the stony ground when removed too deep; in this case the lower side will require strengthening, which may be done by removing the surplus soil from the little cuttings that may occur, and which are possibly close at hand. The washing of soil down these carriages is found to stop their porous bottoms. In favourable situations the carriers may be cut with a common plough to the required width and depth, by which means they are more easily and cheaply cleared of the soil, and afterwards trimmed and levelled to the required form. By the circuitous route of a water-carrier in a hilly country, passing as it does from hill to hill around and across the valleys, a splendid opportunity is afforded for reconveying any quantity of the accumulated soil in "the valley" to the poor and neglected "hill-side," which has been robbed for ages of this deposit by the continued and ungoverned washings of the rainy seasons. In valleys, when drained, the soil quickly decomposes and dries, forming a rich "black mould," which is dug from the upper side of the carriage, and when chopped rather small is thrown into it; then if a rapid fall can be given to the water for a short distance, it will reduce itself so small as to mix with the stream. The "waterman" is in attendance at the meadow, that the soil may be properly distributed, and to change the rush of soil and water further on, as the work proceeds. The same plan may be adopted on the "flat meadows," at the foot of the hill, a heavier soil being used when it can be had, as these bottoms are chiefly composed of black or other friable soil.

The carrying out of this plan will depend much upon local circumstances, choosing at all times the period of high waters (after rains) for washing down the soil, especially when placed at

a distance, or in difficult situations for swilling away. The soil removed by the cutting of open water-courses through the valleys, may be washed away to the dry hill-side meadows by this plan, without ever being thrown out upon the banks, as also the after slopings of their sides to the required batter; this is both a cheap and useful practice. In every case where the surface-water from the uncultivated hill lands has to form a part of the waters, to keep up an even and general supply it is found absolutely necessary to improve them in some way or other. The longer distance peaty water has to run the better it becomes for irrigation, as a sediment is deposited in its onward course; hence the water gradually purifies and improves. To effect a proper change in these waters, arrangements should be made along the main carriages (which take their rise from the brook-course at the foot of the uncultivated hill, and wend their way through the respective meadows) to form sheds for young cattle upon them, that the dung and urine may daily mix with the passing stream. These sheds are placed at the higher end of the meadows, a short distance above the water-carriage, just leaving sufficient space between for the passing of the cattle. Upon the main water-course, and opposite the sheds, a small pond is formed for the reception of the manure when thrown from the cattle-shed; the water on its route thus passes through the pond, and by mixing with the manure and sewerage from the shed, becomes changed for the better, and the effect is certain and cheap.

After the season for watering has passed away, and the stream has been turned off to its original or new course formed to convey it to the brook—the cattle removed to other fields—the meadow sown with a few grass-seeds (if necessary)—effectually cleaned, brushed, rolled, and laid up for hay, to be again supplied and used at the sheds for reproduction, the pond or dung-pit is cleaned out and thrown into a heap to decompose, upon which a covering of peat earth may be thrown, and the whole heap turned and mixed about twice during the summer months. When the season for irrigation again arrives, the compost in its decayed state is thrown into the passing water, and thus conveyed to the meadow without the aid of horse and cart, and the compost thrown down to the water instead of up to the cart. The pond or pit may be used during the summer for collecting soil (sediment) from the passing water (after it has been emptied), and let off to the bottom as opportunities offer. It is further desirable to form compost-heaps during the summer for the same purpose, and to plan conveyance by accumulated surface or flood-water, where spring or brook water cannot be had; the result of this plan will entirely depend upon the active operations of the "waterman" and his men at such a passing period.

The practice of bringing a stream of water to and through the

farmyard is a good one, whereby the "water-wheel" for the purposes of the farm is amply supplied—the waste water passed through the yards and under every office, to collect and wash out the sewerage of the whole establishment, and then pass it away to a pond at the outside of the buildings, from which the adjacent meadows are watered. Many parties condemn this process of collecting and using the liquid manure, and consider the plan of a tank, &c., for the use of the arable land to be preferable.

The tank system is good for arable districts, where the above plan cannot be carried out; but in my case I much prefer the former plan, embracing, as it does, simplicity and cheapness; and as the water filters when passing over the meadow, nothing is lost, but all is deposited where required, and thus produces early and abundant grass for pasturage for soiling in the sheds or for hay.

The water which has passed through my yard upon the above plan, has been used upon a selected portion of hill-side land (as an experiment), which in its natural state was partially covered with rough grass and heather, while on some parts not a plant of any kind was ever seen to grow, as may be seen by reserved spots above the present water carriages; while that below, upon which the water has been used, is now covered with green and daily improving grasses, the chief of which is the white or Dutch clover; and, singular to state, not a single seed has ever been sown upon the land.

Again, by means of the stream passing through the yards, any portion of the farmyard dung may be thrown into it and washed at leisure to the different meadows below, and at periods when possibly horse labour might be invaluable for other operations on the farm. Arable farmers may object to this process; but let them weigh well the advantage in my case, against the laborious movements of the tank and liquid manure-cart in their own. Should the extent of land suitable to the formation of meadows exceed the supply of water upon a farm, and only one turn of watering be afforded during the season, much may be done by the aid of ponds placed at convenient spots—for instance, where small streams or water-carriages meet. Even a moderate supply of water upon this plan will water from 8 to 10 acres of land. In fact, "ponds" are invaluable upon any farm, as a constant fermentation goes on when water accumulates, by which the water is turned green, and thus is charged with ingredients forming (as they do) a sediment (mud) which is deposited at the bottom, for after use; in addition to this the water is found much improved for the purposes of irrigation. During certain periods of the summer season these ponds may be made exceedingly useful by collecting during the day a quantity of water, which may be let off at night; for instance, when the hay is removed from a meadow,

one turn or night's watering may be given it, or the land in other situations damped for a time to produce extra feed, during the dry periods of summer.

When the pond is put in use, care should be taken to stir up the mud at the bottom, until gradually and entirely drawn off, by means of a plug and socket placed at the lower point of the pond and adjoining the carriage for emptying. The self-acting pond is let off by means of a plug and bucket: thus, so soon as the water rises in the pond above a certain level, the bucket fills, and by its weight of water lifts the plug at the other end of a lever, hence the water flows out at the plug-hole until the water in the bucket ceases to run, through a small quill-hole, it then becomes closed—but for a time. This is an excellent plan in showery weather, and saves much attention of the "waterman." This pond is also well cleaned by "stirring" at periods when the water is in use upon the more inferior parts of the meadow. It is an excellent plan to include a portion of dry land in each meadow (above the water-carriages); the cattle and sheep will adjourn to those spots for lair, and apparently much to their comfort. Turnips may also be thrown upon these dry lands as occasion may require, and they are thus equally well manured with the rest of the meadow.

The most convenient size for a water-meadow I find to be from 5 to 6 acres—the watering, mowing, or changing of stock being performed with greater facility and the hill side better sheltered; observing to have the longest fences (if possible) running north and south, that the greatest amount of shelter may be afforded against the prevailing south-west or western gales. We commence watering with the first autumnal rains, as they wash down the accumulated animal and other deposits of the summer, which together afford immense results; if allowed to pass away neglected the cream of the season is gone for ever. Certain meadows are well eaten up by this period, to receive the early waters, after which they are left for a time to afford new and healthy pastures for the latter months, and the water laid on to other meadows which have been prepared to receive them in due succession—hence it is that a number of meadows are found most desirable. The most valuable aid of the "watered meadow" is, in the early spring months, a period of scarcity for the ewes and lambs. Shelter by plantations is a great help to the meadow, warmth being the leading feature for the production of early grass. This advantage is foreign to my farm, the watered lands being laid out upon the naked and uncultivated hill side; but steps are being taken in the direction of the required end. This brings me to the importance of having all new fences (where practicable) laid out by the "spirit-level;" that, while some may be formed to collect

the surface water from the upper lands to a certain point, most eligible for a pond, others may be arranged to convey the water from the pond to the nearest meadows. By this plan the "water-carriages" are made when the "sodfence" is erected, consequently included in its cost—a saving of at least a shilling per chain—the carriage formed in an otherwise useless dike, and the land saved on which the carriage would otherwise have been cut. In laying out these "water-carriage fences" care should be taken that the little irregularities in the line of levels are properly adjusted, that no extreme cuttings or bends be made in the fence, but that each small cutting may produce sufficient soil for making good the small slopes where they may occur from the straightening of the line of fence. This practice is desirable in a hilly country, as immense falls of rain take place at certain seasons of the year, which must be quickly carried off by natural or artificial means. Nothing can exceed the loss of a hill farmer, if the fine particles of soil, manure, lime, or ash, be washed to the bottom of the hill, by collecting currents—never, alas! to be regained; while no pleasure is so great as to witness a collection of these agents (on their way) in a pond or reservoir, with every facility to remove them at will when and where we like.

Water-carriage fences are now (where practicable) universally adopted upon this property, especially in the divisions of the table and hill-side lands, the upper table-lands being set out for the arable farm, and the hill-side for "catch-meadows." These levels are laid out under the joint direction of myself (on the part of the landlord) and the tenant; the tenant erecting the fences and repaid at the succeeding rent-day. An experienced person versed in the art of levelling, is kept to take all the necessary levels for the tenants, in the formation of these fences and subsequent water-carriages, free of charge; and a liberal "tenant right" allowed at the end of the lease for all unexhausted improvements that have been made in carrying them out. The facility and encouragement thus afforded by the landlord is duly appreciated, and it is interesting to notice the consequent effect. New meadows are being laid out upon nearly every farm, the desire being to unite the uses of the water-wheel with that of the meadow below the yards, which is universally arranged to receive the sewerage and water after it has passed the wheel.

The valleys upon my farm are narrow, and contain many springs at the side and foot of the several hills, which from their long and unmolested course had formed dangerous bogs. These springs have been drained by a cheap process, and the water put into immediate use for irrigating the lands below. The plan adopted is by taking the levels, for the water-carriages, from a point at which a level may be driven up to the spring at a proper

depth to effectually carry off its water into the water-carriage below, and it thus mixes with the passing water, and at once takes its part in redeeming the grasses of its late and nearest neighbouring bog below, which had been tapped upon the same plan, and is passing its water in an onward direction for similar improvement. Care should be taken to tap these springs deep enough, as they are much increased by irrigating the upper hill side, especially upon porous soils.

In draining a valley near my house which had formed itself into a regular swamp, it was found necessary to cut an open water-course up the middle (from end to end), observing to cut through the accumulated peat-earth, and at least from 6 to 8 inches into the rock or rubble below. By this means the emptying of the old underground drains is ensured, which had washed their way to a considerable depth, but by occasional stoppages, quaking bogs appeared, dangerous to pass. The open course completed, and the springs cut into it, the work was left for a time to see the effect; after a time one or two upright springs were found to remain, which were tapped and carried into the open course. These drains were filled with stones in the usual way. The valley is now dry and cultivated. The peaty sides of the open water-courses are being sloped and thrown into the stream, and washed to the dry hill-side meadows by its own water. The better plan is to mix lime with these soils during the summer months for using in the autumn. Ponds are being formed at convenient slopes by the same process; and as the soil is required for washing on to the meadows, they will be gradually enlarged from time to time as the work proceeds. These are advantages which cannot be practised in flat work, where the fall is slight, but may be adopted with infinite success in hilly districts, especially where the land is too steep to break, and water can be had (even from a distance), improvements may be made, and at a comparatively moderate outlay. By the use of good spring water alone, the heather and native grasses disappear, and improving grasses are seen to take their place. But little effect will be seen the first year, or perhaps two; still the ultimate result will be certain if proper attention has been paid to the continuous and even watering through the season. I would here venture a remark, that many thousand acres of hill-side lands are now lying waste, growing alone "heather and weeds," which might be profitably brought into good cultivation by the aid of capital, enterprise, and good water. Landlords owning such property would do well to enter into mutual arrangements with their tenants, that the hitherto neglected waste be no longer left to nature's clothing, but covered with green and nutritious grasses. This done, it would serve as a key to the whole occupation, by

affording abundance of hay for the winter season, early feed for the ewes and lambs, and, what is best, little manure need be returned to the meadow, but most may be supplied to the arable lands; still a portion of the hay should be used at the meadow to improve the water, as previously named. I have extended the washing out of "black soil" to the cultivated lands (meadows) sown with artificial grasses, and with good effect. These are formed above the steep hill-side meadows, commencing at the point of moderate declivity. No extra expense has been gone into beyond the usual plan of cultivation for the arable lands, viz., by paring and burning the native grass, followed by a dressing of lime and sown with roots, root-crops following with spring corn and grass-seeds in the ensuing year. In the autumn (after the corn has been removed) the "gutters" are laid out and cut, but from the more moderate slope or fall upon these lands they are placed rather thicker than upon the hill-side, and vary much in their direction, from the uncertain run of the land, such lands having frequently two falls, one with the fall of the country, the other to the brook below. Owing to the moderate descent, these meadows are watered the first season, observing to let the water pass over them thinly, otherwise the unsettled mould would wash away and thus prove injurious to the roots of the grass rather than be a benefit.

By far the better plan for laying down a permanent meadow is to follow the root crop with a crop of rape and grass seeds to be fed off with sheep; by this plan the land is both enriched and well settled, by the trampling of the sheep, for the purpose of watering in the autumn. The expense of laying out these meadows may be summed up under two heads, viz., 10*s*. per acre for cutting the gutters or water-carriages, at an average distance of 22 yards (large and small), and 5*s*. per acre for all other works, such as the necessary culverts through the fences, under gateways, &c., flood-gates, hatches, extra water-carriages for fetching distant water to any given point or pond.

The cattle-sheds placed upon the main water-carriages cost 5*l*. each (complete), they being formed in sheltered situations, adjoining or in stone-quarries, by which means the carriage of the stone is saved, and the wood for roofing is given by the landlord (at the wood); these are separate payments to be met by improved condition of the cattle. The extra cross fences for making small meadows cannot well be charged to the water account, still I confess that the meadow will be worth more by the additional shelter afforded by these fences. The meadows formed, gutters cut, and all other requisites supplied, are as nothing without a certain supply of water, and unless accompanied with strict attention to every branch of the undertaking.

VIII.—*Drainage of Hethel WoodFarm.* By Hamilton Fulton.

To Mr. Pusey.

Dear Sir,—In compliance with your request, I have much pleasure in forwarding to you the statement of the facts connected with the drainage of Hethel Wood estate; the details I will at once proceed to give as briefly as possible. This tract of land is a late purchase of Sir John Peter Boileau, Bart., of Ketteringham Hall, whose zeal for the most liberal promotion of agricultural and other improvements is well known in the county of Norfolk. It contains about 154 acres, and is situated in a nearly level and table-land district of about 4 square miles in extent. Indeed, such is its flat appearance, that persons in the locality believed it incapable of drainage.

The nature of the surface and subsoil is of a most uniform character, and consists of detrital deposits. With the pulverization of the soil, which has been going on for ages without proper drainage, it has become a compact and inert clay, which extends to a depth of from about 1 foot to 18 inches: underneath this the soil is composed of a similar description of clay, but has numerous nodules of chalk, and is consequently of a more marly character than the surface soil. In this subsoil there are also present pockets of sand; from thence downwards it increases in its chalky properties until it reaches the upper chalk. As regards the inclination of its general surface, it was found, when the levels were carefully taken, that the average fall was about 1 foot in 800. Seeing, therefore, that the fall was so slight, it was thought to be necessary that the inclination of the main drains should be particularly attended to, and the fall economised as much as possible; keeping in view, at the same time, the desirability of making the draft of the minor drains as short as practicable for the same reason, namely, the slight fall. It may be well here also to state that it has been the custom to drain lands of a similar description in this vicinity, by digging trenches 2 to 3 feet deep, and filling them in with brushwood at the bottom; but this system has been found to be efficient for four or five years only. It appears to me that the inefficiency after the expiration of this period is to be accounted for by the gradual consolidation of the particles of clay around these brushwood stems, which stop the passages by which the water found its exit; for these passages must at first be so numerous, and the streams of percolation so divided, that they do not possess sufficient strength to maintain their courses. I know it is the opinion of many that these brushwood stems in course of time will decay, and thereby provide larger passages for

the water; but when the stems once become coated with this clayey substance, and the air excluded thereby, the decomposition of the wood ceases, as is proved by taking out some of the wood which has been buried for years, and appears to be nearly as sound as the day it was put in. The cost of this, with trenches 10 yards apart and 2 feet 6 inches deep, is said to be about 35*s.* per acre.

In the system of drainage adopted at Hethel Wood Farm it has been attempted in every instance to prevent the water from the higher and more inclined surfaces from running upon or into the lower land. Upon the more inclined surfaces the drains have been laid upon an average of 4 feet deep and 30 feet apart. Upon the lowest lands they have been laid 24 feet apart and 4 feet deep.

The lowest lands during the whole of last winter were very wet, and the surface so charged with water, that in walking across them the foot would sink in ankle deep. These wet lands were the first drained, which was at the beginning of February last. The quantity of rain which fell during the early part of the spring clearly showed, by the body of water discharged by the drains, and the improved appearance of the land, that ample drainage has been effected; and there can be little doubt, after the expiration of the present summer, and the cracking of the soil between the drains has been effected and new channels thereby formed, that increased efficiency of the drainage will ensue during the coming winter. The pipes which have been used for the minor drains are 1½ inch in diameter. The pipes for the main drains varied in size from 3 to 5 inches, according to the quantity of water which they might have to discharge. The subsoil dug out, consisting of clay mixed with chalk nodules and occasional sand-pockets, which vary from 3 to 5 inches in diameter, was thought to be valuable for spreading on the surface. This opinion was confirmed by that intelligent and practical agriculturist, Mr. John Hudson, of Castleacre, Norfolk. The quantity amounted to about 90 loads per acre. This dressing must produce an effect upon the land, and make it, in conjunction with drainage, more pervious to moisture, and afford greater facility for the roots of plants to expand, and also tend to decompose the free acids, and also those in combination, existing in the soil in a natural state, and inimical to vegetation.

I was very desirous that the existing open drains should be filled in with proper-sized pipes, by which the chance of neglect of keeping them clear would be obviated, and a considerable surface of land would thereby have been acquired; but the high price demanded for such pipes in the locality precluded their use. As regards the system adopted in executing the work, it may be

stated that the first foot was ploughed out, the rest taken out with narrow draining-spades and the lance-headed tool.

The estimate of the cost of the work was 539*l.* 9*s.*, exclusive of spreading, which amounted to 37*l.* 5*s.*, making a total of 576*l.* 14*s.*; whereas the actual cost was 568*l.* 14*s.* 2*d.*, or 3*l.* 14*s.* 4*d.* per acre. The cost would not have amounted to this, had the manufacturer supplied the quantity of pipes he had engaged to do at 16*s.* per thousand. In consequence of his failing to do this, some of the pipes had to be procured at a cost of 25*s.* per thousand.

It is seldom a case occurs where drainage is likely to be more beneficial; and there is little doubt the spreading of the subsoil, in conjunction with perfect drainage, will enhance the productiveness of the land at least 30 per cent., which advantage, if realised, I think it will be admitted has been obtained at a very moderate cost; for it is stated by Mr. Raynbird, in volume vii. of the Society's 'Transactions,' that the labour of subsoiling, filling, and spreading alone is considered worth 2½*d.* per load, which, at 90 loads per acre, would be worth nearly 19*s.* per acre.

I am, dear Sir, yours faithfully,

HAMILTON FULTON, Civil Engineer.

8, *Great Queen Street, Westminster, June*, 1851.

NOTE.—Mr. Fulton was requested by me to give an account of this drainage, which I understood also from Mr. Hudson, of Castleacre, to be extremely well executed and deserving of public attention; and I wished the more that he should do so, because it seemed desirable to put before the public some other case of cheap draining besides those which have been from time to time published by myself. Mr. Fulton, it should be observed, uses the old lance-headed tool, which is far better than the modern scoop-tool in strong clays.—PH. PUSEY.

IX.—*On Agricultural Buildings.* By Lord KINNAIRD.

To the Secretary.

SIR,—I beg to send you plans, estimates, and specifications for farm buildings, which I think might be turned to some account, especially in England, where such improvements are much needed, in order to enable the farmer to cultivate the land with advantage. The large plan is that of a building which, with one or two trifling alterations, I have lately erected, and I can therefore speak accu-

rately with regard to the expense of putting up such a steading; it is most substantially built of stone, but by substituting brick-work and timber, where these materials would answer the purpose equally well, a saving might be effected. The smaller plan shows how certain portions of the building might be adapted to the construction of a steading suitable for any sized farm.

Many of the large useless barns at present in existence might be made available for a part of the building, or else converted into feeding-boxes. I have also sent a list of the implements I consider necessary for the proper cultivation of land. I think this may be of use, as I know by experience that much money is often wasted in the purchase of implements which turn out to be useless; generally speaking, those made of cast iron are of this class, as they are not fitted to stand the rough usage they must meet with in field labour; all complicated machinery also should be avoided.

I have no doubt that agricultural machines made by other makers besides those I have specified may answer the purpose equally well, but I can of course only speak with certainty of those I have tried, and which I have found most efficient.

The cost of some of these I consider too high, but as they are patented they cannot be procured at a lower rate. The steam-engine is not yet erected, but I have contracted for it at 145*l.* with one of the first-rate makers.

Trusting that the accompanying particulars may be of some little service, as the subject of agricultural improvements is one, I am happy to say, attracting general attention,

I remain, Sir, your obedient servant,

Grosvenor Street, August 18, 1851. KINNAIRD.

The principal Implements necessary for a Farm.

	£.	s.	d.
A six-horse Threshing-machine, complete . .	120	0	0
" horse-gear, with chains for ditto . .	25	0	0
Fanners for cleaning corn	6	0	0
For each pair of horses:—			
Cart 10*l.* 10*s.*, with moveable sides for dung 2*l.* 2*s.* .	12	12	0
Corn ditto for the same axle and wheels . .	3	0	0
Plough	3	10	0
A set of Iron Harrows	3	0	0
A set of Harness	9	0	0
1 Weighing Machine, James and Co. . . .	26	0	0
1 Metal Roller	8	0	0
1 Light ditto	5	0	0
1 Croskill's ditto	17	10	0
1 Drill Grubber	3	0	0
2 Two-horse Ducie Grubbers, wrought iron, 6*l.* each .	12	0	0
2 Rud's Subsoil Ploughs, 5*l.* each . . .	10	0	0

	£.	s.	d.
1 Garret's Drill, 5 feet	20	0	0
1 Horse Hoe	15	0	0
1 Presser with 3 Rollers (two Pressers often required)	8	0	0
1 Grass-Sowing Machine	8	0	0
1 Ditto Frame	1	0	0
1 Horse Rake	7	0	0
1 Hay-making Machine	15	15	0
1 Liquid Manure Cart			
1 Chaff-Cutter (Corne's)	14	0	0
1 Turnip-Cutter (Gardiner's double action)	6	0	0
(Moodie's Turnip-Cutter also useful, 4*l.* 10*s.*)			
1 Cake-Bruiser (Hornsby and Son)			
1 Straw Rope Machine	1	0	0
Norwegian Harrow also useful in some cases, Croskill's, 13*l.* 10*s.*			
1 Root-Washer, Croskill's	5	0	0

Small Implements.

Bushel Measure, 15*s.*; Straw Forks, 2*s.*; Dung Forks, 4*s.*; Shovels, 4*s.*; Scythes, 6 inches, 2*s.* 6*d.*; Hoes, 1*s.* 6*d.*; Biddles, 5*s.*; Sacks, 2*s.*; Rope, 3*s.* 6*d.*; Mouth Bags, 4*s.*; Sheep Net, 2*d.* per yard.

General Specification of the various Works to be executed in building and completely finishing a Farm-Steading, Farm-House, and Cottar-House on the Estate of the Right Hon. Lord Kinnaird, 1850.

Mason-work, &c.—The whole area of the buildings shall be excavated to the respective levels shown on the plans and sections, and the wall-tracks to any greater depth requisite for obtaining a solid foundation for the masonry. These excavations, together with that arising from the drains and manure-tank, together with the rubbish which may accumulate during the course of the operations, shall be removed by the contractor.

The foundations shall be executed with the largest-sized ruble stones, and forming a 6-inch scarcement on each side of the walls, and properly bedded in lime mortar.

The whole exterior and interior stone walls, excepting those of farm-house, will be formed exactly as shown on plans, sections, and elevations, and built with the best thorough band ruble, having the requisite headers, and all to be neatly dressed and level on the beds, bedded and packed solid with the best lime mortar. The walls of farm-house shall be executed with the best hammer-dressed, squared ruble, and the whole of the above work will be neatly pointed on the outside, and drawn in with the edge of the trowel with fine lime mortar.

All the inside pillars and scuntions shall be formed with hammer-dressed stone, neatly squared, and level on the beds.

The whole of the door and window rybats, cills, and lintels, and external corners, throughout the main buildings, together with

those of farm-house, base course, cornices, upstarts, porch, chimney-stalks, cart-shed, and gate-pillars, base and cope of engine-house stalk, shall be completely finished with the best droved hewn work; the rybats to be built regularly out, and in-band, having 5-inch margins, and 1-inch splays of droved work; the heads and tails to be neatly pick-dressed; behind margins to correspond with the ruble work: the external corners shall be similar, having 2½-inch droved margins, and similar sized droved splays; the pillars in every situation, whether of cart-shed or courts, shall be executed with single stones, built in regular courses, neatly scabbled and dressed on the face, and shall, together with the arches of the former, have 1½-inch splays all round the exterior angles of the same; the pillars of gateways to cattle-courts, &c., shall be finished with moulded copings, as shown on the elevations.

Recesses are to be formed in the walls for the sliding doors to protect them from the weather.

The cattle-court, and other walls throughout the building, shall be coped with hammer-dressed stone, neatly rounded and projecting one inch on each side over the walls.

The traviss post-stones, with those in cart-shed, will be 18 inches square, and 9 inches thick, with holes cut in the upper bed of the same, for the reception of the posts, and all to be neatly droved.

The group and staw stones in byres will be neatly hammer-dressed, and of the proper sizes; and the bottoms of the same shall be laid with flag-stones to the proper declivities.

The floors of stables, byres, turnip-shed, bull-shed, tool and gig houses, hay-house sheds for loose boxes and passages leading to the same, will all be causewayed with straight-faced stones of the proper sizes, set on soft sand, well packed together, and solidly rammed down, and all to have the proper declivities and water-channels to suit the various drains. The barn-floor will be made up 9 inches with broken metal and chips, and blinded with sand. This floor, together with those of corn-room, cottar-houses, privy, workshop, kitchen, and offices of farm-house, shall be laid with smooth-faced and droved pavement, of the usual sizes; all to be bedded and jointed with fine lime mortar or sand, as the case may be.

The floor of cart-shed, straw-barn, and other houses not already specified, shall be made up with clay, solidly rammed together; finished on the top with gravel, neatly smoothed on the surface, and hard rubbed in.

The travisses in byres will be executed with flag-stones of the requisite sizes, and all the ports and upstarts jibbled checked.

The whole of the walls in every situation throughout the build-

ing shall be beam-filled. The engine-seat and all the openings for the machinery shall be formed with large-sized droved ashlar, as shall be directed.

The boiler and stalk shall be formed with brick-work; the former to have fire-brick flues all round, and communicating with the latter. The engine and boiler-house floors shall also be laid with droved pavement.

The liquid manure tank will be formed below the centre loose box, 8 feet deep, 10 feet long, and 4 feet broad, built with ruble stone, and covered with 4-inch flags. The extent and situation of all the drains throughout the buildings are shown upon the plans, and will be formed with common drain tiles, all laid to the proper declivities, and made to communicate with the tank: those from farm-house shall be of tubular stoneware, 6 inches diameter, and run into a cesspool built and placed in the most convenient situation.

The piggeries and privy will be formed with straight-faced pavement, jointed and batted together with iron and run lead.

Cattle courts will be cleared out, about 2 feet on an average lower than the roadways.

The whole of the crooks and bands or rods for rollers for the doors will be cut and run into the stones.

The kitchen court of farm-house shall be neatly causewayed; all the door-steps and plats shall be of droved work. The floor of porch shall be laid with polished pavement of fair sizes. The dairy shall be provided with polished stone shelves, of the requisite number and sizes.

The mason-work of the cottar-houses shall be completed similar to corresponding portions of the above work.

All the necessary raglets will be cut where required.

The lime, hewn and ruble stones, will be laid down on the site by the proprietor; and the workmanship of the same, together with all the other materials, including the above, requisite for the due performance of the works, will be provided for by the contractor for the mason-work.

Carpenter and Joiner Works.—All the openings throughout the buildings shall have the requisite safe lintels, 1 inch in thickness to every foot of opening, and 6 inches of wall-hold, and closely fitted up to the outside stone lintels. The beams, cart-shed, openings, granary-floors, and those over pillars of sheds shall be of the proper sizes, and have 12 inches of wall-hold. The form and construction of the whole of the roofing will be finished, as shown on the plans, elevations, and sections, to the following sizes:—Scantling 6½ inches by 2½ inches; baulks or ties 6 inches by 2 inches; and struts 4 inches by 1¾ inches,—all neatly joined and firmly nailed, and placed 19 inches apart from

centres. The sarking will be $\frac{3}{4}$ of an inch thick, laid close joint, and securely nailed. The sarking over barn and granary will be half-checked, and the whole will be provided with the necessary ridge-pean and valley-pieces.

The whole of the projecting couples and sarking on the under side of farm-house and steading shall be clean dressed, and to have, along with the finials, three coats of the best oil paint.

The whole of the joisting and roofing shall be laid on wall-plates, $6\frac{1}{2}$ inches by $1\frac{1}{4}$ inches.

The joisting over steading will be 7 inches by $2\frac{1}{2}$ inches, having a beam in the centre, into which the traviss posts will be inserted.

The joists of granary will be 9 inches by $2\frac{1}{2}$ inches, placed 18 inches from centres, having also beams laid along the centre and cross heads, $6\frac{1}{2}$ inches square. The barn joisting will be 10 inches by $2\frac{1}{2}$ inches; and the beams for machinery will be 13 inches by 7 inches, and placed as shall be directed.

The floors of granary, stable-lofts, &c., will be laid with white wood drawn batons, clean dressed; and those of the former to be finished with a 6-inch dressed skirting board.

The sleepers and joisting of dwelling-house shall be of similar sizes, placed 18 inches from centres, and all laid with white wood deals, $6\frac{1}{2}$ inches by $1\frac{1}{8}$ inch thick, grooved and feathered on the joints, securely nailed; and all to be cleaned off when finished, and provided with the necessary hearth borders.

The stair to granary will be formed, as shown, with $1\frac{1}{2}$ inch wood; the closing in of stair landing, chaff-house, and machinery, will be executed with standards and dressed deal, securely fixed up. A trap to be provided for access to the stable-loft.

The traviss-posts will be $6\frac{1}{2}$ inches square, tennered into the beam and stone; the traviss-boarding to be 8 inches by $1\frac{3}{4}$ inch, clean jointed, and douled with oak pins, and covered on the top with an iron strap, $1\frac{3}{4}$ inch by $\frac{1}{10}$ of an inch.

The mangers and hacks in stables shall be formed and fixed up to the requisite sizes, and in the usual manner.

Two corn-chests to be provided for the stable. All the requisite runners, iron rods, harness pins, &c., shall be provided for and fixed up by the contractor.

The straw-hacks will be fitted up in ends of cattle-sheds, and along the byres, framed with bottom runners, top pieces, and spars of the usual dimensions.

The whole of the doors throughout the steading will be formed of 6-inch deal boarding, $1\frac{1}{8}$ inch thick, and beaded on the joints, all clean dressed, hung with crook and band or cross-tailed hinges, or on slides and rollers, as the case may be, and provided with all the necessary stock locks, snecks, and bolts, where neces-

sary, and as shall be directed. They shall have three cross-bars on the back, and hung in two or one leaf, as may be found convenient, such as those of straw-barn, shelter-sheds, &c.; to be in two leaves, and these to have the necessary slide-bolts, &c., complete. The doors of cottar's house, and of farm-house offices, to be precisely similar.

The large gates for cattle-courts will be made with stiles 5 inches by $2\frac{1}{2}$ inches, and 3 rails, covered with spars placed 2 inches apart, all securely framed and nailed together. These gates to be hung on posts $6\frac{1}{2}$ inches square, fixed to the wall, and provided with pulleys, chains, weights, &c., complete. The small gates of kitchen-court, &c., to be hung in two leaves, with crook and band hinges, in the usual manner.

The mangers, &c., between the openings of the feeding-sheds, shall be constructed so as to slide up when required, to allow the cattle to pass underneath into the boxes, and likewise to suit for the accumulation of the dung. The rails dividing the loose boxes shall be 6 inches by 4 inches, and made to ship or unship, as may be found necessary, by means of iron turned or kneed hold-fasts, firmly secured into the walls.

All the windows throughout the steading shall be formed of the usual description, and to have the lower sashes filled in with boards, to slide open, and the upper sashes glazed with second crown-glass diamond panes in zinc frames set in wood; those of cottar-house shall be filled in with diamond panes, of the usual description.

The windows of granary and dairy will have the necessary wire trellacing, fixed into an iron frame, and fitted up in the most workmanlike manner.

A roof-light will be placed over the feeding-board, and also one over the engine-house; to be 3 feet by 30 inches, and glazed with good glass. The whole of the window-cases will be bedded with good haired lime.

The whole walls of corn-room and grain-lofts will receive one coat of plaster, well rubbed in. The privy shall be fitted with seat, door, and skylight complete.

The stair in dwelling-house shall be of wood, framed and fixed up in the most substantial manner, and provided with neat cast-iron balusters and birch handrail.

The staircase shall have a large roof-light and ceiling-light, fixed and framed up, and glazed with strong glass; that of the latter to be obscured.

The whole of the walls and ceilings of the dwelling-house, &c., shall be strapped and lathed with the best American yellow pine split lath. The ceilings and partitions of the cottars' houses shall also be lathed.

The timber partitions shall be framed and fixed up in the usual manner, and double lathed.

The upper floor shall get the requisite deafening-boards between the joists.

The windows shall be framed of the usual description; double and single hung, with all the necessary apparatus; and finished with bound shutters and backfolds; bound ingoings and soffits and architraves to suit the various apartments. Those of offices and cottar-house to be of plain deal linings.

The interior doors shall be bound $1\frac{3}{4}$ inch thick, four-pannelled and moulded to suit, and provided with the requisite locks, hinges, and brass furniture complete. The entrance door to be bound $2\frac{1}{4}$ inches thick, four-pannelled, and hung with strong hinges, provided with strong iron-rimmed lock and furniture, complete. These doors to be provided with all the necessary door-posts, and finished with single and double faciad architraves, set on blocks, to suit the various rooms; those of offices, &c., to have plain facings. The principal rooms and lobbies shall have moulded base plates, and the others moulded skirting-boards of the usual dimensions.

The wall-presses shall be lined, and get, together with all the closets, &c., three rows of shelving, from 12 inches to 15 inches broad.

The sink and wash-tubs shall be fitted up in the usual manner.

The whole of the outside doors and windows throughout the buildings shall receive two coats of the best oil paint.

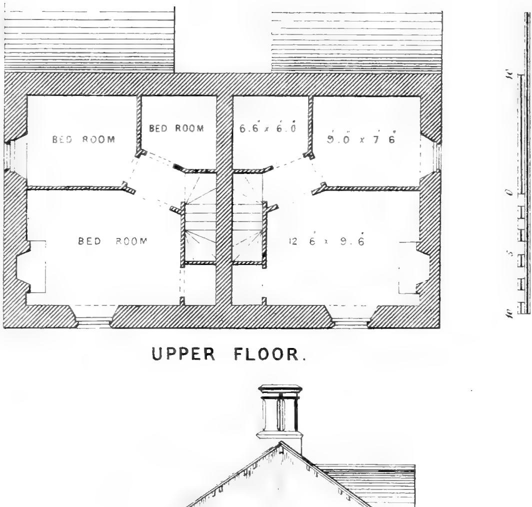
The windows of dwelling-house only shall be glazed with the best crown glass, and to be properly primed.

The whole of the interior finishings of the dwelling-house shall be done with the best American yellow pine; the windows and doors, roofing, joisting, beams, lintels, and gates of the best crown Memel; the flooring and lining of plain deal doors to be of white wood batons. The sarking over stables and byres, of similar batons, and the other parts of American yellow pine. The trevis posts, boarding, mangers, &c., and other interior fittings of the steading, to be of the best larch fir; all to be of the best quality, and free from sapwood or large knots.

The carriages will be driven by the proprietor.

The cottar-houses will be finished precisely similar to other buildings of the same kind, and like corresponding portions of the works above described and referred to.

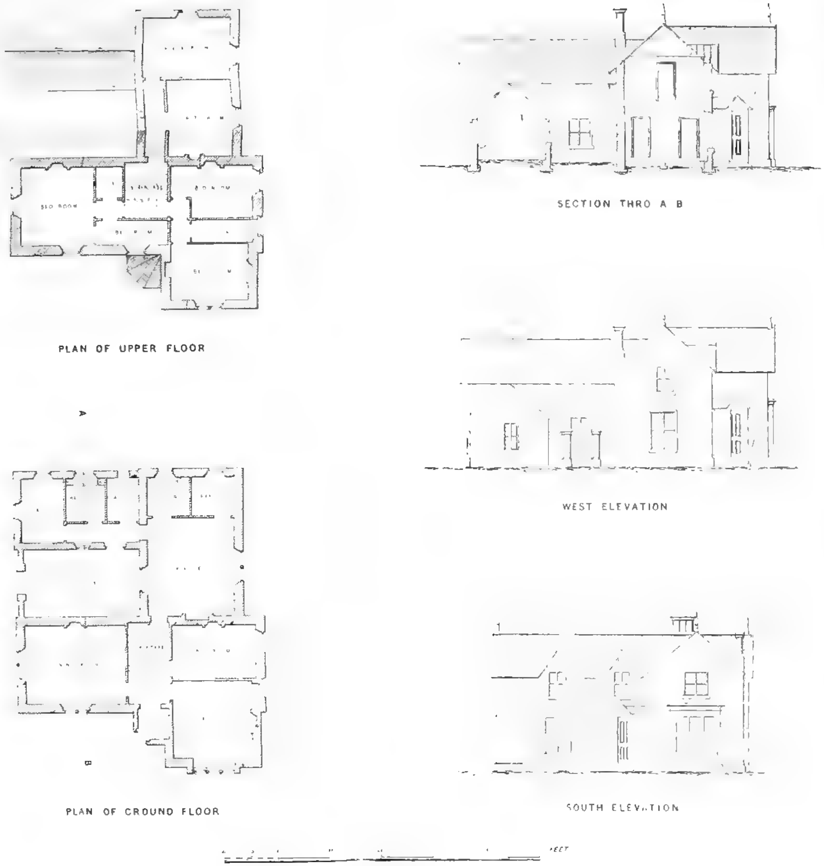
Slater and Plumber Works.—The whole of the roofs shall be covered with the best under-sized Ballochulish slates, hung with zinc nails, and having the proper band and cover, and all neatly dressed square, and bedded in lime mortar. The ridges, peans, and flanks shall be covered with the best 18 oz. zinc, of the usual



UPPER FLOOR.

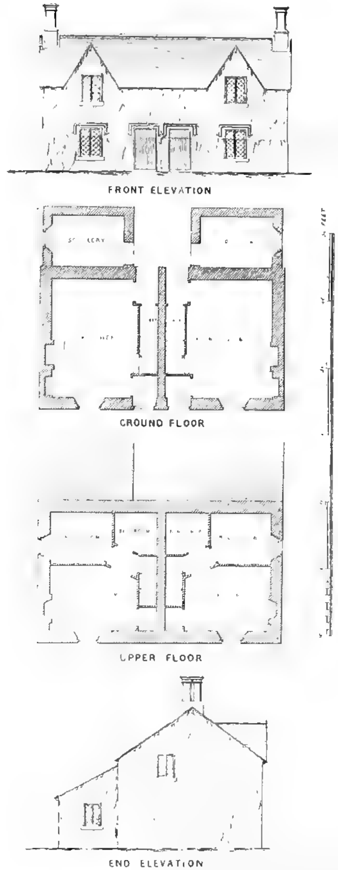
END ELEVATION.

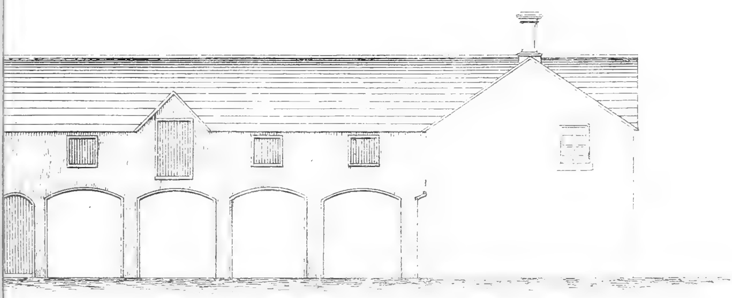
PLAN OF FARM HOUSE.



DESIGN FOR DOUBLE COTTAGE ON THE ESTATE OF ROSSIE PRIORY.

1850





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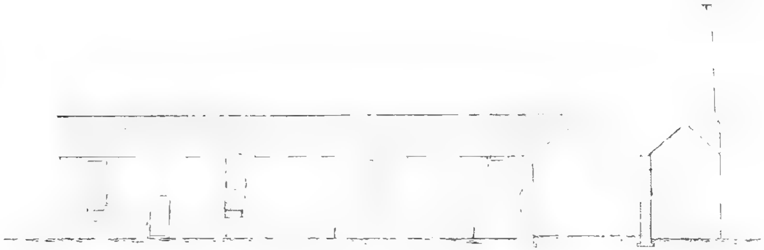

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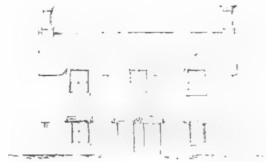
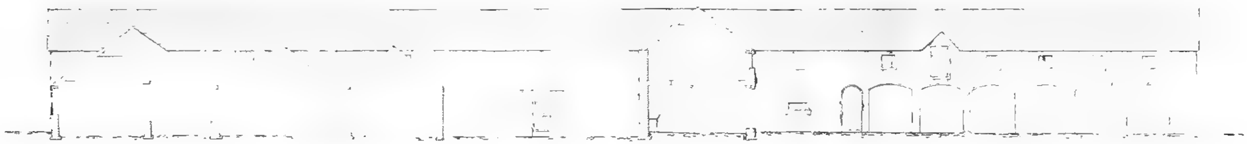


ELEVATION OF COTTAGES



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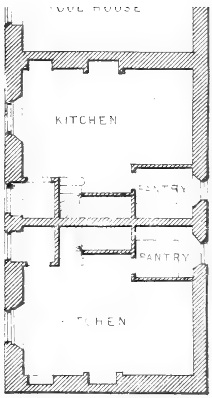
ATION N A B



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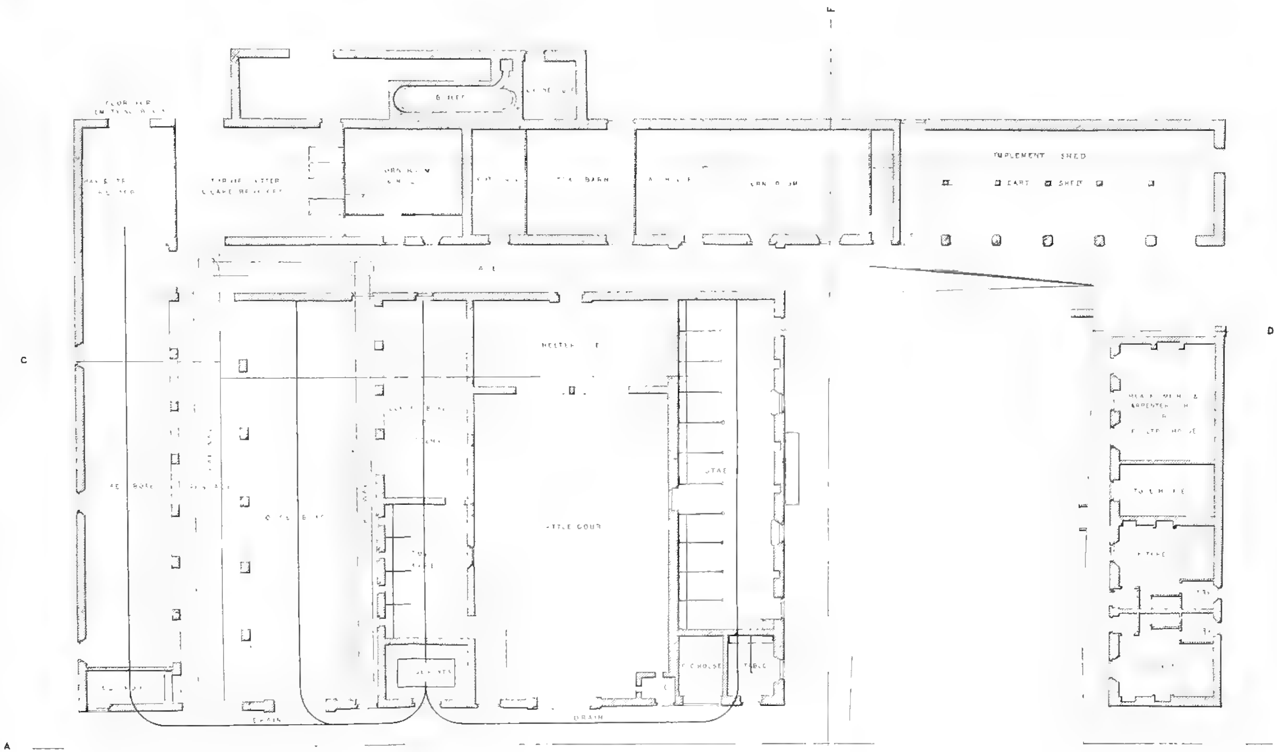
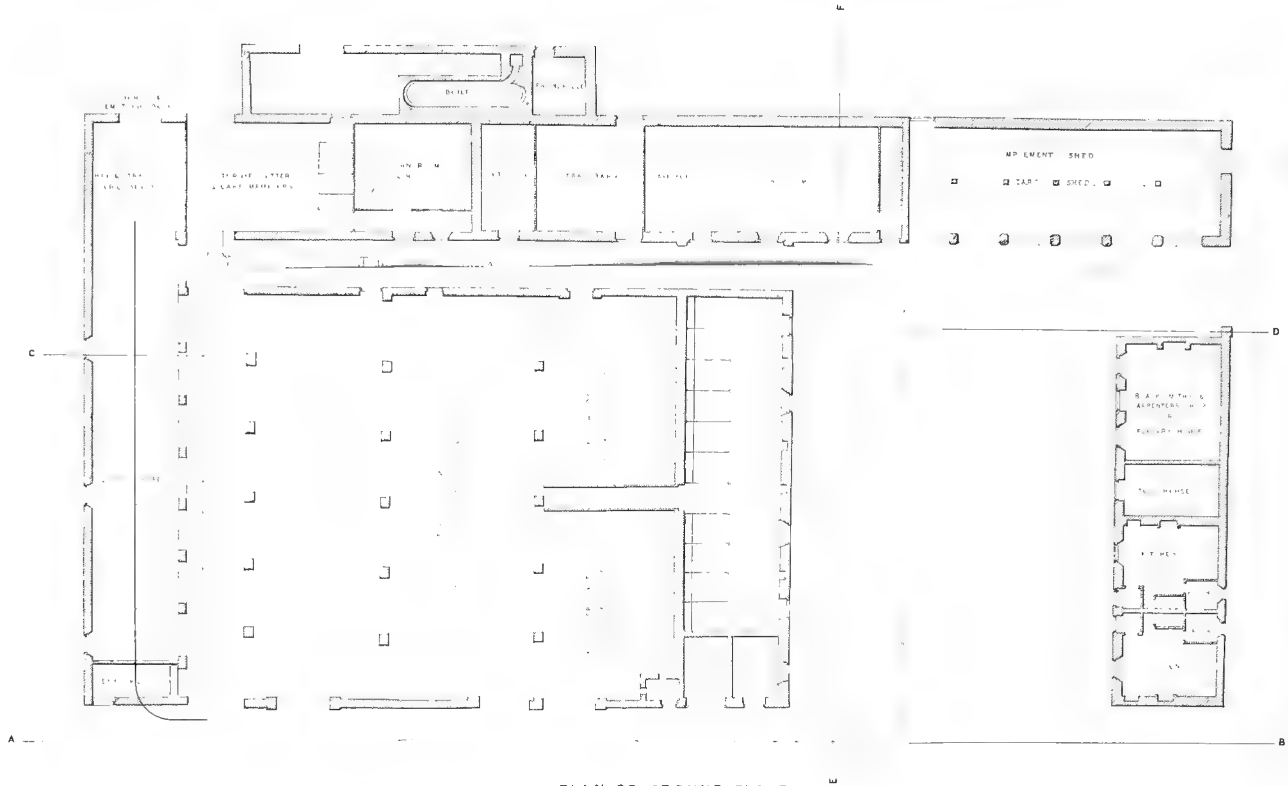
Standidge & Co. Litho London.



PLAN OF GROUND FLOOR.

Scale



PLAN OF GROUND FLOOR

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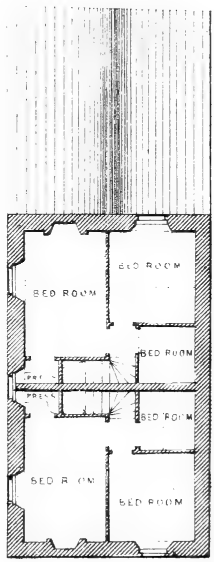

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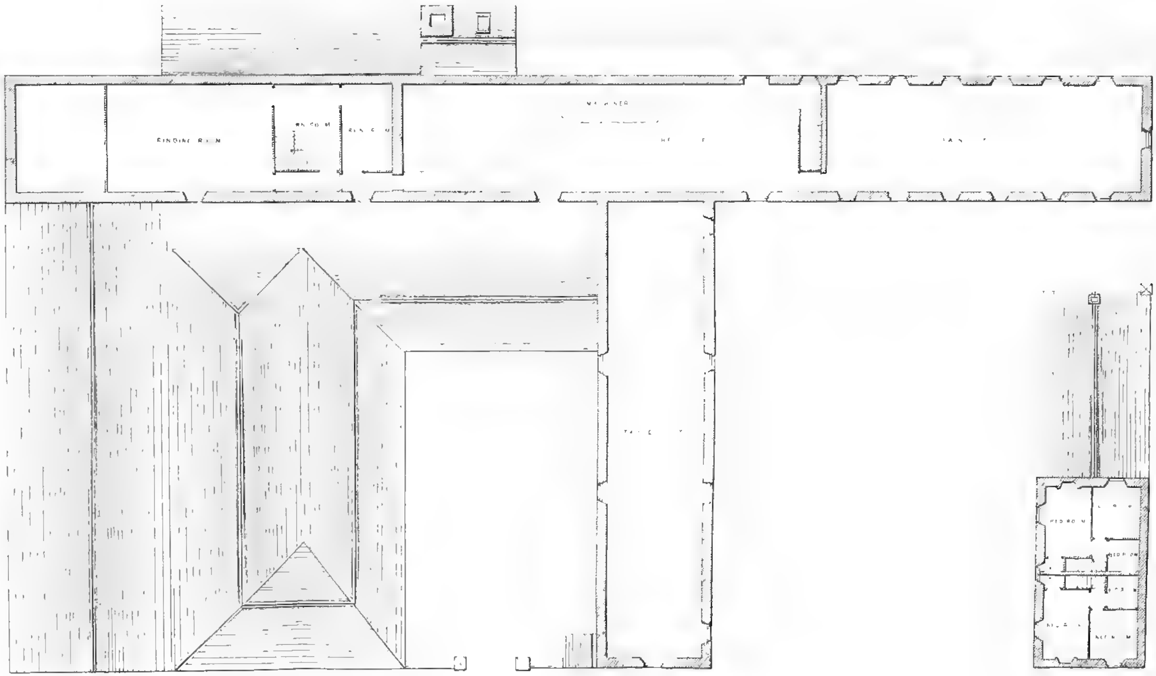

PLAN OF UPPER FLOOR.

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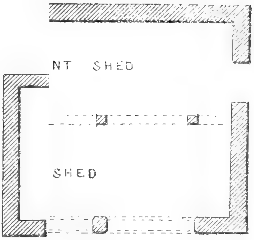
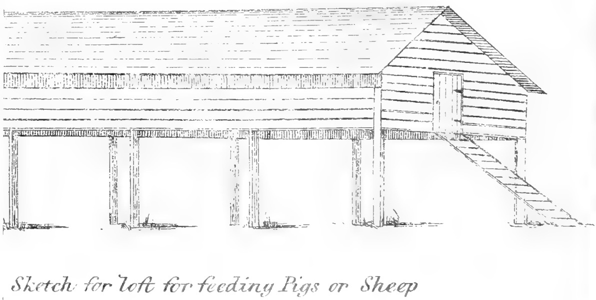


.ANS FOR SMALL FARM,

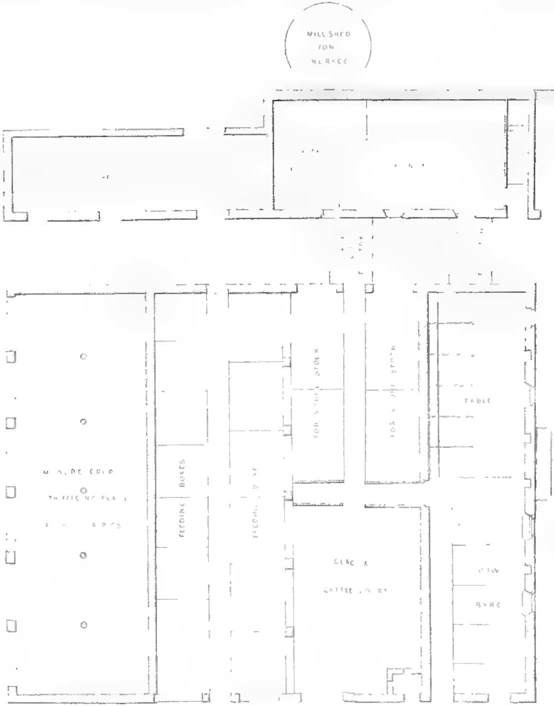
FROM PORTIONS OF LARCE PLAN,

nd 2 and Stable lofted, by which
Straw Barn is saved.



Sketch for loft for feeding Pigs or Sheep
with Manure drop.

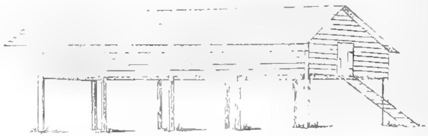
Standidge & C^o. Litho. Ol. Jewry.



PLANS FOR SMALL FARM.

TAKEN FROM PORTIONS OF LARGE PLAN.

Sheds 1 and 2 and Stable lofted, by which Straw Barn is saved.



Sketch for Loft for feeding Pigs or Sheep with Manure drop

description; and all the chimney-stalks shall have the necessary gutter-lead, of 6 lb. per foot.

The roof-lights shall have the necessary flashings, of 5 lb. lead.

The carriages will be driven by the proprietor.

Plaster Work.—The whole of the walls and ceilings of the cottar-houses shall be finished with two-coat plaster. The whole of the interior of every place and apartment throughout the dwelling-house and offices shall receive three coats of plaster; and the upper floor shall be deafened in the usual manner.

The principal rooms and lobbies shall get plaster cornices of suitable sizes, and all the beads to be double cut. The carriages will be driven by the proprietor.

The whole works, as described in this specification, although not particularly specified, and with reference to the various plans, elevations, and sections, must be completed in the most substantial and workmanlike manner, and to the entire satisfaction of the proprietor, his architect, or any person that may be appointed to examine the operations.

The whole of the above works, including *all materials* and workmanship furnished by the contractors, exclusive of carriages, were or can be executed for the following sums, viz.:—

Farm-steading—	Mason-work . .	£680	
	Wright-work . .	740	
	Slater and plumber works	240	
		——	£1660*
Cottar-houses for two families from . .			£100 to £110
Farm-house and offices complete (estimated) at .			£450†

Smaller steading—	Mason-work, including asphalte floors .	£310
	Slater-work and tiles, including plumber-work	125
	Carpenter and plaster work	570
		£1035

* A saving might be effected, so that the cost would not exceed 1500*l.*; while the smaller plan annexed might be executed for about 660*l.* less.

† The farm-buildings face the south, and ample ventilation is provided; the north end of the cattle-sheds being open to the cross passage, and air being admitted at the south end as required. Light is obtained by the insertion of glass tiles or slates, and water supplied by means of an elevated cistern, which is filled by the engine or hand-pump.

The gutters between the roof are formed of wood, covered with sail-cloth and a preparation of Archangel tar, &c., whereby a great saving of lead or zinc is effected. The idea of the feeding-loft is taken from one in use on Sir John Conroy's farm.

X.—*On Mr. M'Cormick's Reaping-machine.* By Ph. Pusey, M.P.

Although the Report on Agricultural Implements is not yet drawn up for the Royal Commission, still the new American Reaper is so important to farmers, that having, with Mr. Miles and Professor Hlubach, myself tried it for the Council medal, I venture to communicate to the Royal Agricultural Society a very brief account of that trial.

The machine, drawn by two horses, and carrying two men, a driver and a raker, cut the wheat about eight inches from the ground with the utmost regularity.* The horses found the work light, though the machine was cutting at the rate of 1½ acre per hour, making 15 acres per day of 10 hours. The raker, standing behind the driver to rake the cut wheat from the platform, certainly had to exert himself; but it is obvious that he and the driver, who has only to sit on the dicky, might very well exchange places from time to time. As one cannot put a high price on the labour of farm-horses at such a time, it is plain that a great saving must be effected by this machine, and every farmer can calculate it for himself, as he will also see the advantage of being rendered independent of the arrival of strangers to get in his corn, who cannot always be found. This trial was witnessed by many farmers, and no fault was found with the work. The land, I should say, however, being stock land, is even; where ridges and water-furrows exist, some difficulties seem to arise. But, on this level land, it was wonderful to see a new implement working so smoothly, so truly, and in such a masterly manner. The fact is, however, that it is not an untried implement. Though new in this country, it has been used for some years in America, where experience has enabled the inventor to correct in successive seasons the defects invariably found in new implements. It is certainly strange that we should not have had it over before, nor indeed should we have it now, but for the Great Exhibition, to whose royal originator the English farmer is clearly indebted for the introduction of the most important addition to farming machinery that has been invented since the threshing-machine first took the place of the flail.

Pusey, August 20, 1851.

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* Mr. M'Cormick informed us that, by a slight change of construction, he has made the implement cut two inches nearer the ground.

XI.—*Essay on the Rearing and Management of Poultry.* By William Trotter.

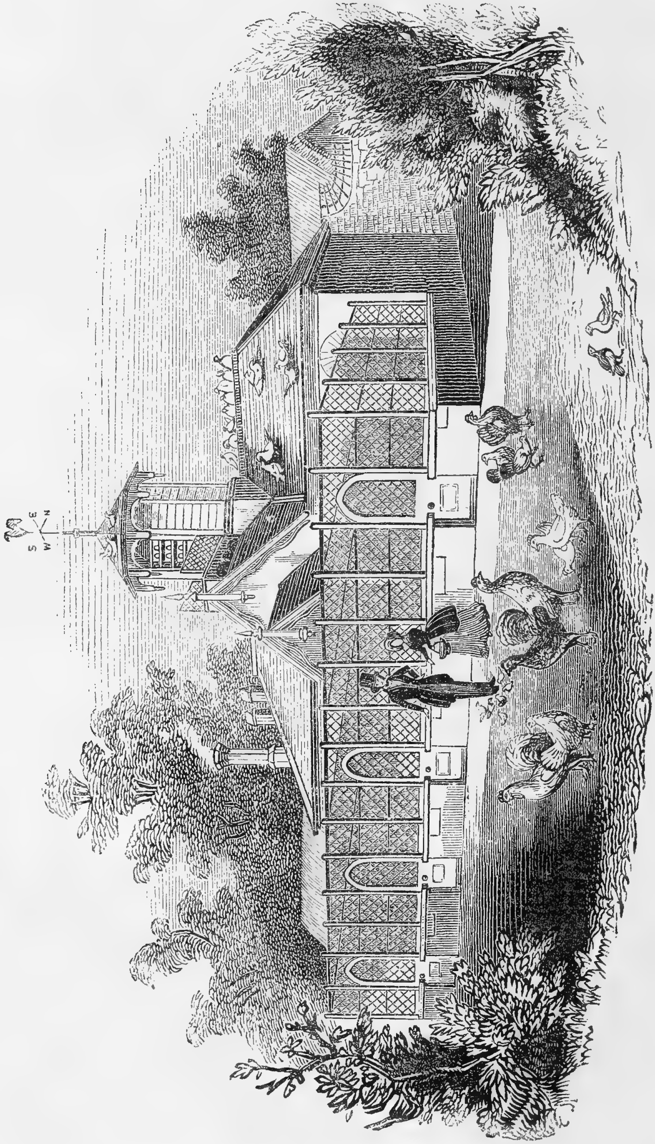
Prize Essay.

Poultry is assuming that position in the agricultural world which its importance demands. The prize offered by the Royal Agricultural Society of England for the best "essay on the rearing and management of poultry" will undoubtedly be the means of inducing many to turn their attention to this department of farming —a department too lightly looked upon, and one from which, if properly conducted, a good profit is derived.

If this Society would, at its annual country exhibition, offer prizes for the best of the various breeds of poultry, the exhibition would not only be more interesting, but would bring before the public, in almost every locality, specimens which are too little known. In the district (Northumberland) from which we write, the fowls are almost invariably of the dunghill breed, which is not so profitable as many others, and which is kept in consequence of the best varieties not being known; whereas, if the different Agricultural Societies were to give prizes for poultry, those varieties would soon be spread throughout the length and breadth of the land, and, as a natural result, in the management of which there would be more improvement, a great obstacle to which is the want of sufficient accommodation. We shall, therefore, in the first place, take into consideration the construction of poultry-houses: for without sufficient accommodation, not only will the time required in attendance be considerably increased, but the profit will be greatly curtailed. I will not lengthen my paper by describing the many buildings erected for the purpose by resident landowners: however, I should deem it an omission were I not to allude to that belonging to her Majesty.

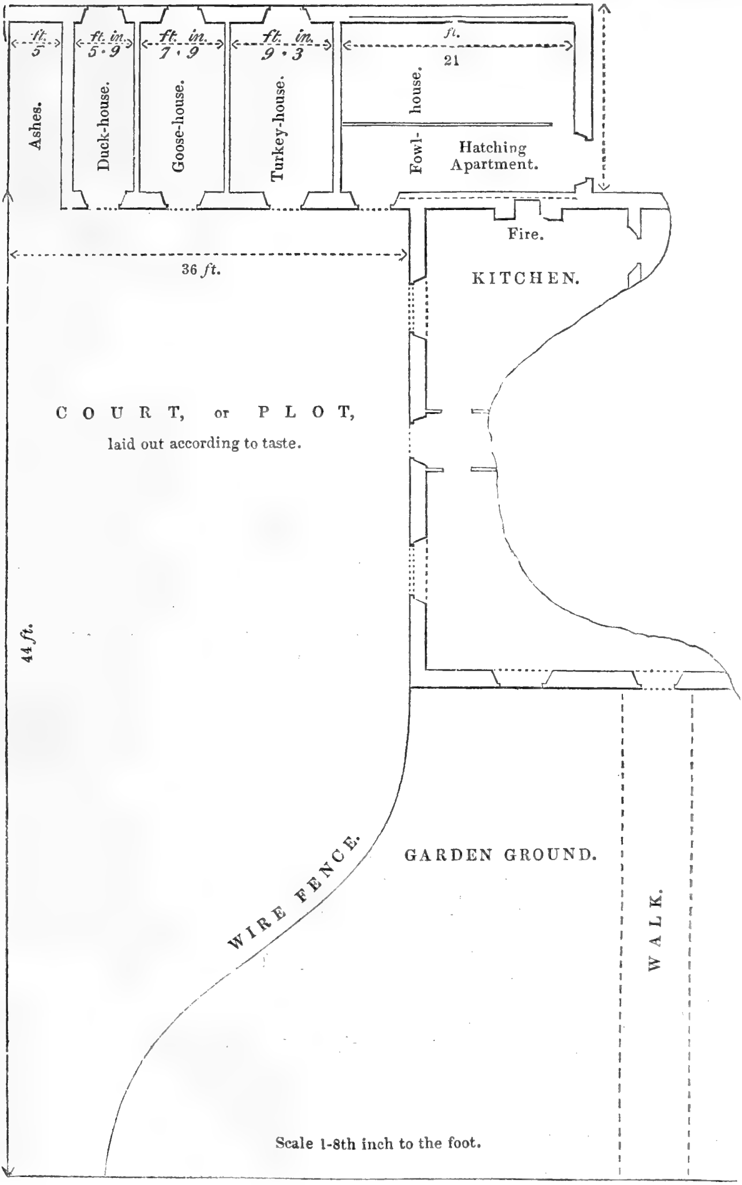
The building is of a semi-Gothic style, situated in the Home Park, Windsor, and consists of a central pavilion for feeding, and from whence the fowls can be inspected. This pavilion is flanked by roosting, feeding, and setting-houses, a hospital for the diseased and lamed. In front is a large court, divided by slight wire fences into compartments as walks for the daily exercise of the fowls. Each compartment consists of grass-plots surrounded by gravel walks. In constructing the building, the natural habits of the birds have been constantly kept in view; the apartments are large and airy, the temperature of which is at the command of the attendants. The laying-nests are (copied from such as the

hen chooses, when allowed to select for herself) composed of heath, with hawthorn branches trained around and over them.



The Queen's Poultry and Poultry-house, Windsor.

Having thus briefly noticed her Majesty's aviary, I shall proceed to describe such a building as I think is in every respect



Scale 1-8th inch to the foot.

adequate to the profitable keeping of poultry. The annexed sketch will enable me to illustrate my meaning.

The fowl-house, as is seen in plan, stretches across the end of the kitchen, and has the advantage of being kept sufficiently warm by the kitchen-fire. Many people object to having the poultry-houses so closely connected with the dwelling-house, and justly so, if the excrement of the poultry be allowed to accumulate for weeks; but such accumulations form no part of the good and profitable management which we would wish to have invariably adopted. In no other situation could the poultry be so profitably kept, for, in consequence of having the advantage of being warmed by the kitchen-fire, there is either an increased number of eggs, a less consumption of food, or the two combined. True, the poultry-house might be kept warm independent of the kitchen-fire; but this would involve no trifling expense, not only in the construction and attendance, but also in the consumption of fuel.

The temperature of the body of at least all warm-blooded animals remains the same in winter as in summer. The heat is generated by the decomposition of food; when the temperature of the air which surrounds the body is low, then the body gives off considerably more heat, and hence an increased amount of food is required: or sufficient nutriment is not left for the production of eggs. As a natural consequence in cold weather, if the hens are not protected from it, a falling off in the number of eggs is invariably the result; it is, therefore, of great importance to have the poultry kept warm.

Moreover, with the arrangements I recommend, the mistress of the house, whether attending to the domestic duties of the kitchen, or when entertaining a friend in the parlour, will have the young poultry in the plot continually under her eye—a thing essentially necessary.

The Fowl-house.—The fowl-house should be divided lengthwise into two parts, either by lattice, wire, or by net; the last answers well, and will last a great number of years if painted or tarred when put up. The house thus divided must have a door between each compartment to admit the fowls into both at all times excepting the hatching season. We shall enter more fully into this in the chapter on hatching.

The floor should be cleaned at any rate once every week, and as much oftener as possible. To facilitate this operation the floor should be of flags (with a descent of about 1 inch in 24 to the door), and raised six inches above the level of the surface. It should be covered over with dry sawdust, ashes, or peat, any of which is a valuable addition to excrement as manure; but

that which I most recommend is peat charcoal. It may not be out of place to remark here, that the manure, to prevent it losing its best properties, should be placed under cover. The walls, the best material for which is bricks, should be plastered, and must be whitewashed four times a year.

Recesses 14 inches high, 12 inches in length, and 12 in breadth, must be left in the front wall 4 feet from the floor, and extending to about 14 inches from each corner.

These recesses must be fitted up with a box 5 inches high, either with or without a bottom, for hatching-nests. A deal 8 inches broad must extend across the front of the nests for the fowls to alight on; care being taken not to have its ends too close to the corners, otherwise rats, if allowed to enter the building, will avail themselves of it when wanting a feast. The nests should be half filled with soft short straw or moss, dried heath, or fern; neither long straw nor hay ought to be used; the former catches the feet of the hens as they leave the nests, and is apt to do injury to the eggs; the latter has a tendency to produce a parasite of the *louse* tribe.

The laying nests should be constructed in the same way, in the opposite wall; but two rows (one above the other) will be found necessary, as a scarcity of nests induces the hens to lay from home; however, we shall not go so far as Dickson, in recommending a nest for each hen. One nest for every three or four hens is quite sufficient. Hens delight to lay where there is the greatest number of eggs; I have often witnessed contests for nests whilst others were close by and occupied.

Hens, when nursing a brood of chickens, are not always friendly to each other; it is therefore necessary to have a coop for each brood placed against the inside of the front wall, each coop to be occupied by the hen which hatched in the nest above it.

Six roosting-balks should be fixed in the back apartment, commencing about 3 feet from the floor, and 2 feet 6 inches from the wall; each successive balk should be about 12 inches higher and 10 farther from the wall. All writers whom I have consulted recommend the balks to be placed higher: but when fowls are wanted, I have found great inconvenience in getting them off high balks.

The front apartment should be fitted up with two balks about 14 inches from the floor; on these the young chickens will roost. We have observed that the hens in our poultry-house choose their nests in the darkest situations in which to lay. If the habits and tastes of the hens should have their influence, then, of course, the fowl-house must not be kept too light.

Ventilation.—Nothing can have a more pernicious effect on health than a polluted atmosphere; it is therefore of the utmost importance that the ventilation be of the most perfect description. I am not fully aware whether the air, which has done its work in respiration, should be taken off at the top or bottom of the house. During each respiration a volume of air is received into the lungs, and an equal volume of carbonic acid gas is thrown off.

Carbonic acid gas is heavier than pure air when they are both of the same temperature, but when thrown off by the lungs, it is, in consequence of its increased temperature, specifically lighter than the surrounding air, and it consequently rises until an equilibrium is established. Should the gas and air combine, it matters little at what point or elevation the poisoned air be taken off; but should they not combine, or only partly so, then, I distinctly say, take away the air from the bottom, for no sooner will the gas become of the same temperature as the air than it will fall.

As I would rather incur the liability of lowering the temperature of the apartment than I would have an unwholesome atmosphere, I recommend two openings, one to be about half way between the floor and roof, the other to be as close to the roof as practicable. To prevent too sudden a draught, a deal 12 inches square should be placed before each opening on the inside, about an inch from the wall. The openings should be about 4 inches square. To get the air taken from the bottom, a pipe of about 3 inches diameter might be conducted from within say 6 inches of the floor, and continued up one of the corners of the kitchen-chimney.

The doors must be made in two parts, so that in hot weather the upper part can be kept open while the under part is closed. To admit the ingress and egress of the fowls there must be three openings, 12 inches high and 10 broad, with shutters on the inside—one opening to be at the front, and the other into the back yard, from whence the fowls should have a free range over the whole place. The openings should be high enough to clear the nests, and provided with hen-ladders inside and out. That which composes the bottom of the openings should extend at least 4 inches beyond the wall on both sides.

The Turkey-house.—The turkey-house adjoins that occupied by the fowls, the size of which should be regulated according to the number of turkeys kept. No bird is more delicate when young, nor more hardy when old, than the turkey; their house must therefore be constructed with this peculiarity in view. The balks should be placed higher, by 3 or 4 feet, than those in the fowl-house, and accompanied with a hen-ladder. Large lattice

windows should be placed in both sides of the house, and made sufficiently wide to admit a free current of air as soon as the turkeys are old enough to require it. The house should have two doors, similar to those in the fowl-house, one opening to the front and the other to the back. We shall take the situation of the nests into consideration hereafter.

The Goose-house.—On many farms geese are not kept, therefore a goose-house is not wanted. Where they are kept, a house adjoining that occupied by the turkeys is in the best situation. We need say little respecting its construction. The great thing to be attended to is cleanliness. The house should be very frequently cleaned, and the floor strewed with some dry material, in the same manner as the fowl-house.

The duck-house should be kept in the same manner as the goose-house, and, should there be a loft, it will be an excellent place for pigeons.

In concluding my remarks on the poultry-houses, I beg to insist on the necessity of having the ground on which they stand most effectually drained. The rain-water should be carried from the roof by spouts. Every possible means should be used to keep the building free from dampness; especially as the health of the poultry greatly depends on the dryness and comfort of their habitation.

Grass-plot.—In the plan I have adopted, a grass-plot in front of the house is almost indispensable. As to its dimensions, it should be about 40 yards in length, and 20 in breadth at the widest end. It admits of being tastefully laid out with gravel walks and shrubs. Gravel is indispensable, for without it poultry could not be kept in perfect health for any length of time; the shrubs will afford shelter from both sun and rain. A small quantity of *slaked* lime should be placed in some convenient corner. As fowls are fond of rolling themselves among dry ashes, on no account should they be deprived of this amusement, and, moreover, there can be no doubt but the ashes are pernicious to the vermin with which all poultry are more or less infested. The ashes should be protected from rain.

Poultry should at all times have free access to *pure* water; it is therefore highly necessary to have a trough placed in the plot. If a stream of water can be brought to it, nothing more is required; but should this be impracticable, fresh water must be *daily* supplied.

The trough must be covered in a way to prevent the young chicks from falling into it; open wicker-work will answer the purpose better than anything else, care being taken not to have the spaces between the rods so large as to admit a chick to pass,

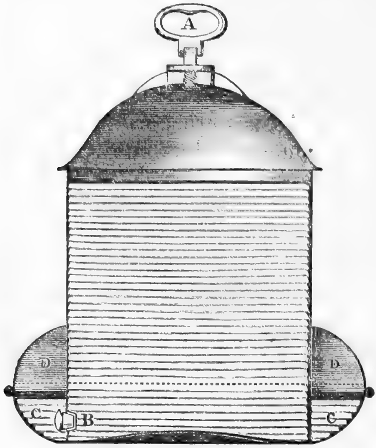
but sufficiently large to permit the heads of full grown fowls. The trough should stand about 10 inches above the surface.*

Rats.—Rats are exceedingly troublesome in the poultry-houses, and every means should be made use of to prevent their entrance. They are fondest of those eggs which have been longest sat upon. To have eggs destroyed when within a few days of yielding their fruits is too annoying to be endured, especially when the eggs are of a valuable sort. The mason-work should be of such a description as to make it impossible for a rat to gain admittance. The joints of the flags of the floor should be perfectly close.

It may not be out of place to state, that I have found phosphorus, made up according to the recipe which Dr. Ure communicated to the Council of this Society (Royal Agricultural Society), very efficacious in destroying rats. It is stated that it is *fatal to rats alone*: how far this may be relied on I cannot say, but this I know, that we had two pigs and two valuable fowls that died at the time when we had this poison laid for the rats. But I was from home when the accident took place, and, consequently, had not an opportunity to examine the contents of their stomachs to ascertain the cause of death.

Selection of Variety.—The different varieties of fowls possess peculiarities which make them suitable for some localities and unsuitable for others, otherwise I should not have advanced one word on this subject, as I deem it irrelevant to the subject for which the prize is offered.

In this district (Northumberland) no person of discretion (unless independent) would breed such fowls as have no other recommendation than that of being good table-birds. The best price



* Since writing the above, the writer has had an opportunity of inspecting a fountain, manufactured and registered by Mr. John Bailey, 143, Mount-street, London, for the purpose of supplying poultry with water, and the construction of which is such, that while the poultry has the advantage of having the water constantly within reach, yet they cannot get into it to destroy its purity, or to do injury to themselves. The annexed cut represents a section.

procurable in our market is not more than 1*s.* 6*d.*, while the prevailing prices are 1*s.* 2*d.* and 1*s.* 4*d.* each for fowls.

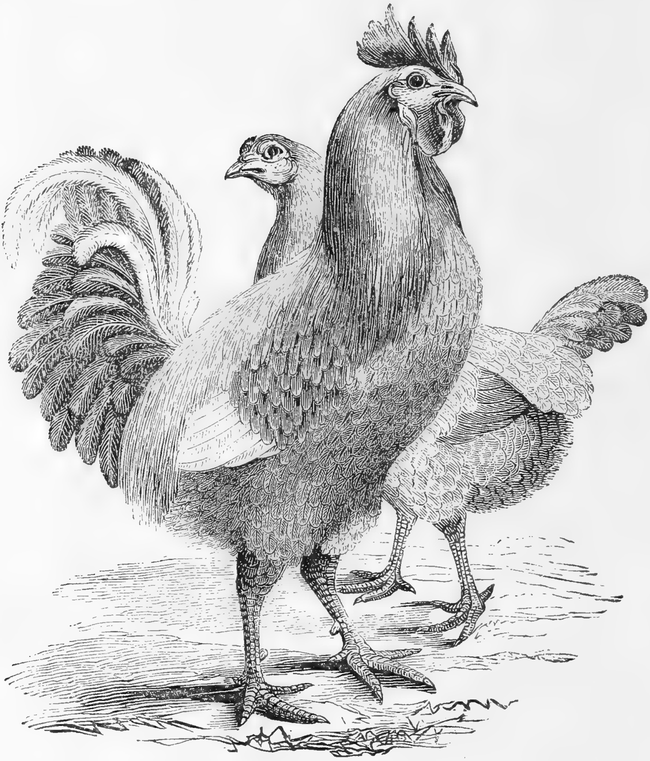
Hens of the best laying varieties will lay in a season from 160 to 270 eggs each, averaging 215; which, being sold at the very low price of 11*d.* per score, will realise 9*s.* 10¼*d.* for the produce of one hen for one year, By comparing the price of chickens in our market and the value of the produce of a single hen, it will at once be obvious that it is not so profitable to keep varieties which are better adapted for the table than for laying.

If we take the neighbourhood surrounding the metropolis or other localities where chickens sell at twice, and in some instances at thrice, the above prices, such varieties as are suitable for the table may be profitably kept: hence I think I shall not be digressing to an unpardonable extent by giving such hints on *selection* as from experience I feel myself able to do. We shall best do this by giving descriptions of the peculiarities of the best varieties; in doing so, I shall not follow in the track of the writers of olden times, who only had that variety to choose from which is now designated as the barn-door or dunghill breed—which, since we have imported so many others, is worthless, or nearly so. It is of all shapes and colours, if we may so speak: hence the folly in giving directions to select stock from such a breed, as there are seldom two of the same colour in one brood.

The Cochin-China Fowl.—Some years since, specimens of this breed were forwarded to her Majesty's aviary. Of late it has attracted considerable attention. Between it and the Malay some writers do not discriminate, regarding them as merely "*domestic* varieties." But finer fowls have recently been imported, displaying so much originality as at once to stamp them as not only a distinct but an esteemed variety. The most striking difference is in the combs. The comb of the Cochin-China is single, of moderate size, and slightly serrated; while the comb of the Malay presents the appearance of having been cut off.

The eggs laid by the Cochin-China hen are not above the average size, of a light chocolate colour, and of superior quality.

The late talented H. D. Richardson, Esq., in his work on 'Domestic Fowls,' states on the authority of the Right Hon. Mr. Shaw, the Recorder of Dublin; her Majesty's poultry-keeper, Mr. Walters; and Mr. Nolan, of Dublin, "that the hen sometimes lays two or three times a day, and within a few moments of each other." With such authority the fact can scarcely be doubted; but in justice I acknowledge I know of no instance of a hen having laid more than one *perfect* egg in a day.



Cochin-China Fowls.*

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* "The above fowls were presented to our most gracious Queen, and afterwards bred at Windsor Great Park; and, in order to promote their extension, given by her Majesty to such persons as were supposed likely to appreciate them. I have been fortunate in procuring some fine specimens of them soon after their arrival. Three of the Queen's birds were exhibited at the Royal Dublin Society's show, for 1846, which elicited the gold medal; but they were evidently crossed by the Dorking, as evinced by their general appearance, and being partially furnished with the additional toe—a circumstance admitted by Mr. Walter, the Queen's poultry-keeper. This lot was subsequently presented to the then Lord-Lieutenant of Ireland, Lord Heytesbury. At the same show I exhibited the first Cochin-China fowl, of pure breeding, in this country. The annexed figures are taken from them, by Mr. William Oldham."—NOLAN, *Domestic Fowl and Game Birds*, p. 8.

Cochin-China Fowls.*

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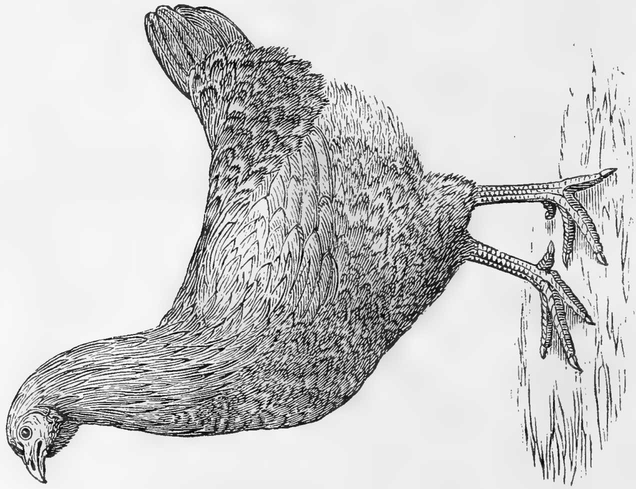
* These representations are engraved from drawings of what the author considers the best specimens of Cochin-China fowls of the day; and are here given along with the engravings of that breed occurring in the series of Mr. Nolan's illustrations.

The Malay Fowl.—This breed is from the Malay peninsula, situated on the southern point of the continent of India, from



Malay Hen.

Malay Cock.

whence the breed obtains its name. There is a great disparity in size between the male and female. The cock stands high on his legs, has a very long neck, and is, in our opinion, in figure and carriage, not a bird to be admired. The flesh is not of the best description. The hen is by no means well-shaped, but a good layer. The eggs are of choice excellence. Although

this breed has obtained considerable notoriety, yet, in consequence of consuming an immense quantity of food, it cannot be recommended.

The Spanish Fowl.—The Spanish fowls are almost invariably clad in black plumage; a few show a white feather; on such we

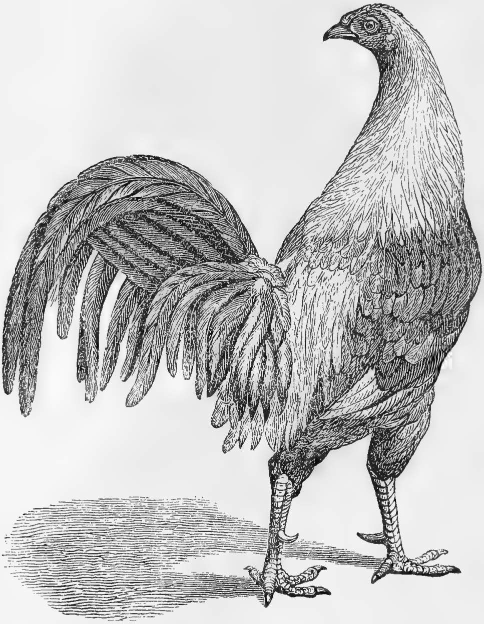
Spanish Cock.

Spanish Hen.

look with suspicion, although birds of the purest description have been known to change from *black* to almost *white*. The comb and wattles are exceedingly large, the former single and serrated. The greatest peculiarity of this breed is a *white* or a *bluish-white* cheek. The legs are of a dark lead colour. Since the first time

I saw a pure bred bird of this kind, I have admired it. Its bearing is graceful and stately. Its flesh is all that can be desired by the most fastidious epicure. The hen lays a fine, large, and delicately-flavoured egg. She is a most abundant layer, and can scarcely be surpassed by any other breed. Should she have one drawback, it is in the largeness of her eggs. Large eggs do not bring their relative value; and it would be ridiculous to suppose that they do not require more nutriment to produce them than smaller ones.

The Game Fowl.—This variety, which was at one time so carefully bred on account of its indubitable courage in the ring, is,



Game Cock.

we are happy to say, not now wanted, in consequence of its pugnacity, except by the "poultry-fancier," or by a class of men who stand low in the estimation of the public. I might therefore have passed it without remark, had not its beauty been the theme of universal admiration by all lovers of nature. Who ever saw a well-bred bird of this breed, at a lonely cot, in full plumage, without seeing an animal as perfect as can be imagined? All his bearings are graceful in the extreme, and his colour delightful. In size this breed is less than many others. The flesh is of prime quality. The hens lay well, but do not rank in the first

class; the eggs are small, but in flavour they are not to be surpassed.

The Dorking Fowl.—The Dorking breed of fowls derives its name from a town in Surrey of the same appellation. From the

True Dorking.

excellence of its flesh, from its plumpness and great weight, it has derived a celebrity for the table unrivalled by any other breed. It may be justly said that "its qualities surpass its charms." The hens are not to be equalled as sitters; hence the breed is peculiarly adapted for districts where table-birds are in request at remunerative prices. The hens are very good layers. Some say that those which are white are the only pure breed; this is a matter of opinion. The most prevailing colours are spotted or spangled, in various shades. The fowls of this breed have five toes on each foot; a peculiarity, if absent, denoting impurity of blood. From protuberances in the feet, these fowls are very much predisposed to lameness.

This breed degenerates when removed from its native place. Situation will undoubtedly have great influence, but I attribute this degeneracy more to a want of "fresh blood" and mismanage-

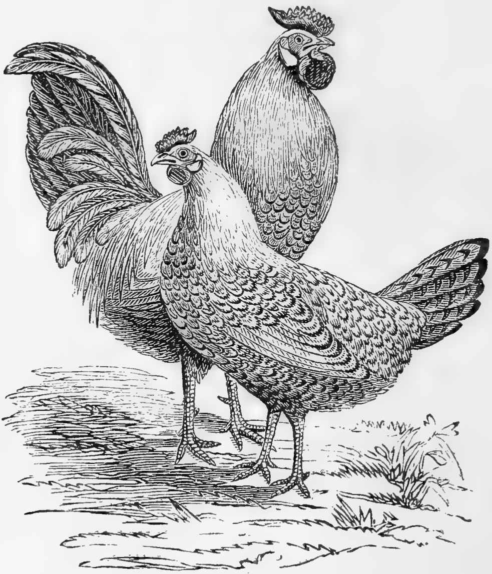
ment than to the influence of climate. All animals bred in and in sooner or later degenerate. When this breed is considerably removed from its native sphere, the practicability of getting "fresh blood" is greatly reduced.

Sussex Fowl.—The Sussex breed of fowls is closely allied to the Dorking, and is in quality equal to it. The body is more elongated. The fifth toe is almost invariably absent, and it is therefore less predisposed to lameness.

The Dutch Every-day layers.—Of all fowls which have come under my notice, none equals the Dutch every-day layers in the production of eggs. I acknowledge the eggs to be a little less than the average size, but not to such an extent as to materially interfere with their marketable value.

A gentleman of great experience has kindly favoured me with the number of eggs he obtained from four hens of this breed. The average for three months was no less than twenty-six each week, each egg weighing 2 oz.

The hens commence laying at the early age of four or five months; whereas the larger breeds seldom commence to lay before they are twice this age. This is no trifling recommendation.



Dutch Every-day Layers.

Of this breed there are two varieties distinguished only by colour: the one is termed the "golden spangled;" the other, the

"silver spangled." To describe them minutely would be going beyond the precincts of this paper. I may be permitted to remark that this breed is often confounded with the "spangled Hamburgh," and also with the "black Polish;" the differences between which I shall notice when I describe the latter varieties.

The Dutch every-day layers derive their name from the fact of the hens continuing to lay, rarely evincing any disposition to incubate.

In size this breed is equal to the average size of the game fowl. They are exceedingly well shaped; in their movements they are very majestic and graceful.

The "silver spangled" of this variety is in some localities known by the name of "Bolton greys."

The Polish Fowl.—Of this breed three varieties have been noticed by writers, one of which is supposed to be nearly extinct; from the description given of it, I infer that it must have been really beautiful. "Both the cock and hen were of a pure glossy white, with a large black top-knot."

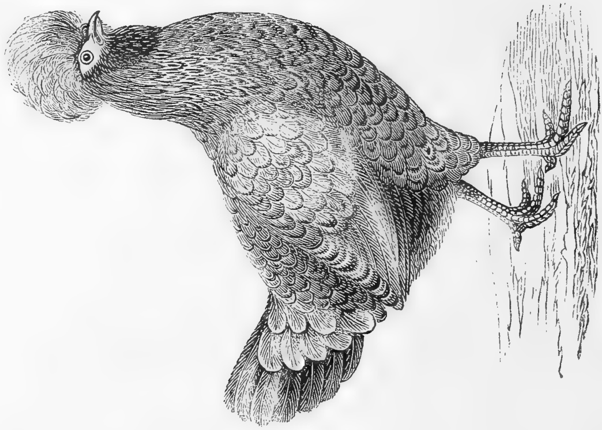
The next variety is of black plumage, with a large white top-knot, and of good figure. The hens are abundant layers, and, like the Dutch every-day layers, seldom show any disposition to sit, and have in consequence sometimes received the name of "every-day layers;" hence this variety has often been confounded with the Dutch every-day layers.

The other variety of the Polish breed is known by the name of "spangled Polish." This variety, from its scarcity, from the extraordinary beauty of its plumage, from the good quality of its flesh, and from the hens being so very prolific, is very difficult to obtain. It has no comb, but crowned with a large top-knot.

The Spangled Hamburgh.—Of this breed there are two varieties, the "golden" and the "silver spangled." It commands a high price; but not so much for its good and profitable qualities as for its beauty and scarcity. It is sometimes confounded with the "spangled Polish," and, as I have before stated, also with the Dutch every-day layers. They are, however, easily distinguished from each other. The Dutch has a large rose comb; the Polish, instead of a comb, has a large top-knot; while the Hamburgh has a small comb rising into two or more flesh-horns, behind which is a large brown or yellow top-knot.

The Bantam.—I should not have given the bantam a passing remark, were it not for the fact that it is the only breed which can be successfully employed in the rearing of pheasants and partridges. There are many varieties, the most celebrated of which is that brought to perfection by Sir John Sebright.

Spangled Hamburgh Cock.



Spangled Hamburgh Hen.

There are many other breeds of fowls, but not possessing those properties which would recommend them to any but the curious or "fancier," the principal of which are the following:—

Turkish fowl.
Dwarf fowl, or cruper.
Rumkin.
Frizzled fowl.
Silky fowl.
Negro fowl.
Prussian fowl.
Barbary fowl.

Having now given a short, but I trust a sufficient, description

of the peculiarities of the best breeds of fowls, I will next say a few words on the selection of breeds.

The breeder must in the first place ascertain whether he can obtain most profit from the sale of eggs or from the sale of chickens. How is he to come at this? I say, without going into details, if he can obtain two shillings each for chickens, that he may select fowls which are best adapted for the table; if he cannot obtain this price, then he must select such as are known good layers—such as seldom show any propensity to propagate their own species by incubation.

Table Fowls.—If it be found desirable to breed for the table, then the Dorking is what I recommend: and, moreover, the greater the number of chickens that can be reared from the same number of eggs, the greater is the profit; success, therefore, to a great extent, depends on the qualities of the hens as sitters and as nurses. Here again the Dorking stand preeminent, for better sitters and nurses connot be produced. Some fanciers of repute recommend a cross with this breed and the Malay or the Cochin-China. I cannot subscribe to this recommendation, unless the objects to be obtained are an increase in offal, and a decrease in the qualities of the hens as sitters, especially if with the former. If a cross must take place, as some writers say, to renew a degenerating race (be it observed I do not admit of this, from the very simple and obvious fact of the Dorkings of this day being as heavy as any Dorkings that have come under our notice of past dates), let the cross be with a well-shaped bird, of small bone, and undeniable flesh. The Spanish, possessing these qualities in an eminent degree, is the only bird I would recommend to cross with the Dorking. Attend to what the late very talented naturalist, H. D. Richardson, says in his work on domestic fowls, when speaking of the Spanish:—"As table birds they hold a place of the very first rank, their flesh being particularly white, tender, and juicy; and the skin possessing that beautiful clear white hue, so essential a requisite for birds designed for the consumption of the gourmand." W. C. L. Martin, "late one of the scientific officers of the Zoological Society of London," is, in his treatise on poultry in Knight's *Farmers' Library and Cyclopædia of Rural Affairs,* no less liberal in his remarks in praise of the Spanish fowls. I therefore have the best authority to substantiate my own opinion of the high value of the Spanish as birds for the table. I have consequently recommended them in preference to all others to cross with the Dorkings.

Many people, when buying fowls for the table, make the colour of the legs the criterion whereby they judge of the quality of the flesh; I may therefore be allowed to state that Soyer, in his

valuable work on cookery, says that those "fowls which have black legs are the best for roasting, while those with white legs are the best for boiling."

Fowls for Laying.—For the purpose of laying, no breed of fowls is better adapted than the Dutch every-day layers. Should their eggs prove rather small, a cross with the Spanish will at once remedy the defect. For our part we are satisfied that (although the eggs are less than those laid by the larger varieties of fowls) yet they are equal to those laid by the dunghill breed. That the eggs of the Dutch are less nutritious, from their great number, is merely speculative and without foundation.

The black Polish is also notorious for the production of immense numbers of eggs. Should its appearance be more in accordance with the taste of the owner, I offer no objections to it.

How to obtain a Good Breed of Poultry.

Number of Hens to one Cock.—The next point we have to dispose of is, Ought there to be any discretion used in proportioning the number of hens to the number of cocks?

Dickson has acquitted himself better on this subject than any author previous to his day whom I have consulted. His remarks are ably followed up by the late H. D. Richardson, who goes on to observe, "that the number of hens allowed to one cock should vary with the object in view."

"If the profit be from the production of eggs alone, one cock may have as many as twenty-four hens. If the object be strong and healthy chickens, he ought to be restricted to six, or at most eight." So far I agree with the author quoted.

If chickens are not wanted for sale, they are wanted to renew the stock of hens. And as no one can deny the necessity of having healthy chickens for consumption, surely no one will deny the advantage of having healthy pullets to add yearly to the stock; which, be it remembered, should not be kept above three years (unless of a valuable breed), after which they are almost useless, even for household purposes.

The stock of fowls in our poultry-yard is kept for the production of eggs, and to keep it up a number of pullets is reared every year. To have the pullets strong and healthy is of the utmost importance. This object could not be obtained without either keeping a great number of cocks, or keeping a small number of hens and a cock in an enclosure. The latter method I have adopted, and strongly recommend it to the notice of breeders of fowls. By it I am enabled to keep a less proportion of cocks than I could else safely have done. Were it not for the received opinion that hens do not lay so well when deprived of the com-

pany of the other sex, it would have been useless to keep a cock. As it is, the number of hens to one cock may be as high as thirty. Recollect we are speaking of the laying stock of hens, and not of the breeding stock. The very eminent French writer, M. Parmentier, if we mistake not, witnessed the productive powers of a cock fifty times in one day. We restrict three hens to one cock, when the eggs are wanted for hatching.

Selection of Eggs for Hatching.—Writers on poultry give directions for the selection of eggs for hatching without noting whether the eggs are laid by the handsomest or by the ugliest hens in the yard; a system which cannot be too strongly condemned. All breeders are aware that "like produces like" in all pure breeds of animals. No doubt there are exceptions to all rules, but, if this maxim be kept in view, the right line will seldom be deviated from. By the method we have adopted of selecting the finest hens to breed from, and by keeping them in a yard with a cock not related to them, and by selecting eggs from those laid by them, considerable advantage is gained over the method of selecting the eggs for sitting from those laid by the whole stock of hens. I give preference to such eggs as are a little above the average size, having always found them to produce the strongest birds. All irregular-shaped eggs must be rejected.

A discovery was made by Columella, and laid hold of by others, of great importance to the practical breeder; as it enables him to select such eggs as will produce male, and such as will produce female birds. I say of great importance, because he who depends on the sale of eggs for profit does not want male birds, and therefore it would be useless for him to breed them. To him Columella would say, "Select the round eggs, for they contain female birds, and reject the oblong shaped, for they contain birds of the opposite sex." "By the position of the air cell at the butt end of the egg, those may be selected which will produce the male sex: in these the air cell is in the centre of the end; if the cell be a little at one side the egg will produce a female chick. The position of the air cell is easily discovered by holding the egg between the eye and a light."

Incubation, or Hatching.—The process of incubation is accomplished either naturally or artificially. None are so ignorant as to require instructions as to how the process is naturally accomplished. There are various artificial methods of incubation, of which I shall speak after having disposed of some important points in connexion with natural hatching; the first of which to be considered is the number of eggs which ought to be given to a hen. In consequence of our abode adjoining a plantation of considerable magnitude, our hens, notwithstanding all attempts to prevent them, often stray to seek nests for themselves. (We

may remark that it is no easy task to find their nests. Should a hen be aware of being watched to her nest, the cunning she displays to avoid detection is alike admirable and wonderful.) We therefore have almost constant opportunities of ascertaining the number of eggs a hen will lay, upon which to brood when left to the dictates of instinct. We have found the number of eggs (when the hens have thus been left to themselves) to range from 11 to 18; of the latter number we have had only one instance, and, strange to relate, every egg produced a bird.

The number of eggs must be regulated by the size of the hen and of the eggs. The eggs of the Spanish fowls being very large, 9 will be a sufficient number for an average sized hen, while as far as 13 eggs of the Dutch every-day layers may be given. Many people are fond of giving a hen a large number of eggs, under the impression that they have a better chance of getting a good brood; in my opinion the reverse is the fact. The hen having more eggs than she can properly cover, some of them must necessarily be exposed to the atmosphere, the temperature of which is considerably below that which is necessary for the development of the chick: the probability is that many or all the eggs may (during so long a period as 21 days) be more or less injured, and as a matter of course the produce must be less healthy. Having duly determined on the number of eggs, and of the sex we wish them to produce (I have known great disappointment arise from the want of a knowledge of the discovery made by Columella), the next object is to find a suitable nest in which to place the hen and eggs. In too many instances this is a task of great difficulty. It is to be regretted that farm buildings are seldom so perfect as to have a proper building for poultry. True there is often a house set apart for this object, but as unfit for its purpose as it can well possibly be. I have ever found it a most difficult thing to get a hen to sit in any place excepting in that where she has been accustomed to lay. If set in the apartment where the whole stock of hens lay—owing to other hens laying in the same nest, and to the disturbance caused by taking from her the fresh-laid eggs—she will seldom succeed in bringing out more than one quarter of the chicks which she, if properly protected, would have done: hence the advantage of the plan I have recommended, of dividing the fowl-house by open work, so that the hens when sitting are in the same house where they have laid, and are at the same time unmolested by the laying hens. The hatching hens have the privilege of the plot in front of the poultry-houses, while the laying hens are carefully excluded from it.

The less a hen is disturbed during the time of incubation the better. It is impossible to do her any service; she will leave the nest to feed and will return to it before any injury is done to the

eggs by cooling: however, we must not on any account neglect to have for her an abundant supply of food. If not well fed she will be less able to cater for her offspring, for, as Cobbett shrewdly observes, "though the hen does not give milk, she gives heat."

Some writers speak of hens that will not leave their nest to obtain food, and recommend meat to be given them when on the nests. Such hens I have never seen; but in cases of the kind, in order to allow a fresh supply of air to enter the eggs, the hen should be taken from the nest to be fed. The shell of an egg being porous allows air to pass through it. When an egg is heated, owing to the expansion of its interior a portion of air is driven off, when the egg cools down (as is the case with the eggs when the hen leaves her hatching nest), a corresponding contraction takes place, and fresh air must enter the egg to supply the place of that which was expelled. The air which enters must be such as is necessary to support life, hence the imperative necessity of ever keeping the air which surrounds the hens when sitting pure, by frequently washing and cleaning the fowl-house.

The time required for incubation is set down at 21 days; this admits of considerable modification. The temperature of the atmosphere and the age of the eggs have both great influence on the length of time: when the weather is cold, another day is necessary. Fresh-laid eggs hatch sooner than those 3 or 4 weeks old; it is therefore of importance to have all the eggs for one hatching as near of the same age as possible.

In an essay of this description it would be useless to detail all the changes which take place in the egg during incubation, and moreover, among men of science, a difference of opinion prevails respecting the progress of the embryo-chicken. However curious and interesting the subject may be to the naturalist and philosopher, it affects not the management and rearing of poultry.

Dickson recommends the birds which come out first "to be taken from the hen and placed in a basket lined with cotton-wool, lest the hen should be induced to leave her nest before all the eggs are hatched." I do not agree with this advice, nor can I admit of any interference. Should the advice I have given be made use of, viz., the necessity of not giving the hen too many eggs, and having them near of the same age, and of having her to sit in the same house where she has been accustomed to lay, at the same time protecting her from the other hens, there will be no occasion for any interference. Some chicks, it is true, do not get so fast out of shell as others, but this is attributable to accidental causes and to mismanagement. When the chick does not make sufficient progress in freeing itself from its shelly prison to satisfy the poultry-keeper, a great inducement is offered

to render assistance. We would that man would let nature have its course. It is a very rare occurrence indeed that any good result is obtained by giving assistance to the chick when in the shell. "Never attempt," says Cantelo, "to free a chicken from the shell, unless the cause of its detention is very evidently an accidental circumstance, which you may know by its loud cries, sometimes caused by the feathers sticking to the shell; but when the chicken is nearly disengaged, or making very violent efforts, there is no danger in pulling open the shell, though the least abrasure of the veins covering the inside of the shell before the blood is taken up by the chicken is always detrimental, and generally fatal. In case, however, of the chicken pecking towards the small end, instead of the butt (which sometimes happens), as soon as it begins to cut round the shell, a piece may be removed, in order to give a little more room for the exit." Such is the advice of one who, in some years, rears as many as eighteen thousand poultry. We imagine nothing more need be said on this subject, for we are certain that there is not one case in a hundred that any good can be done, and were we to give further instructions, we should, like the quack doctors, be putting double-edged tools into the hands of those who are ignorant of their use.

Many people set two or more hens at the same time, in order that they may put the broods to one hen; not a bad plan in an economical point of view, but we cannot admire the system of thus depriving a hen of her offspring, after she has so carefully sat for twenty-one days anxiously waiting the issue. Nor do we think one hen should have more than fourteen birds to cater for and to cover comfortably, and, moreover, a hen will not always take the chicks of another under her care; however, should the brood of one hen have to be given to another, the dusk of the evening is the best time to do it, and whoever has the work to do must be careful, as the mother becomes quite furious when interfered with.

Many attempts have been made to make hens sit at the will of man. With one exception, these attempts have been acts of cruelty, and we cannot too strongly express our disgust at them. The exception I speak of was brought under my notice by having observed the earliest chickens in our neighbourhood were, every year, in the possession of the same person. Attributing this circumstance to something more than mere accident, I was induced to ascertain the cause. The person never kept more than one hen, and I found, in answer to my inquiries, "that the eggs were not taken from the nest, and as soon as she had laid about thirteen, she commenced to sit." This seemed so natural that I at once felt convinced that if hens were to be in-

duced to sit, it was the only rational plan that could be adopted. As I have before observed, our hens lay a great deal in an adjoining plantation. When a nest is found, the eggs are taken away as they are laid, taking care always to leave one. The hen continues to lay, the same as if she had been laying in the fowl-house; but should the nest not have been found, I am convinced that she would have commenced to sit as soon as she had a convenient number of eggs. The same may be said of pheasants. If the eggs be taken away as fast as they are laid, as many as 60 may be got from one pheasant in a season. Again, fowls in their native haunts never lay more in the season than what they can hatch. From all this we may justly conclude that no artificial means are required to induce a hen to sit, but that she does not, in consequence of the eggs being taken from the nest.

In many varieties of fowls there are sometimes, in many districts, far more hens in the hatching mood than are wanted. Under such circumstances, cooping is the only safe remedy. The time of confinement varies, some hens requiring 4 days, while others require 10. It has been asserted by some writers that the health of the hen is affected when not allowed to sit, and that the eggs laid afterwards are not wholesome. This I do not believe.

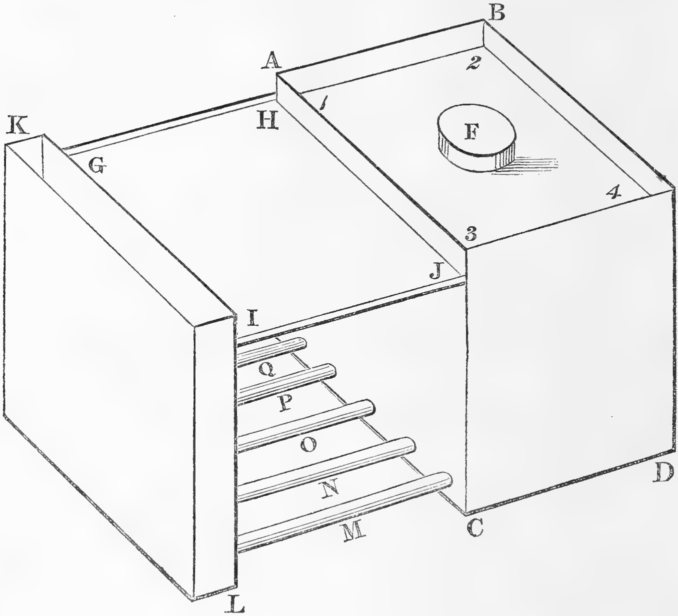
Those persons who keep the Dutch every-day layers should have 3 or 4 Dorking hens to do the hatching business.

I have before stated that the hens which constitute the laying stock are to be excluded from the hatching apartment during the breeding season. They therefore cannot obtain admittance into the plot; consequently the hens, with their broods, cannot suffer any annoyance from them.

Artificial Hatching.—Although artificial hatching has, from a very early date, received considerable attention, yet I must be permitted, in order to keep our paper within proper limits, to describe that method only which I consider the most likely to succeed, and which is the invention of Mr. William James Cantelo, who has for some time been exhibiting his apparatus at 4, Leicester-square, London. This method, by which Mr. Cantelo says he can send to the market 75 per cent. of chickens for the eggs placed in the machine, is styled the "Cantelonian," which differs from others in consequence of the heat being applied to the side of the egg which is uppermost, instead of to the bottom or around it; the advantages of which will be evident, when it is known that the germ, so long as the egg is in a horizontal position, always floats, and that it is this part which comes in contact with the hen's breast. The heat, which is generated by the combustion of gas or charcoal, is transmitted to the eggs by the agency of water. The sketch given below from memory, will,

with the description, give an idea of the principle, construction, and working of the apparatus, detailed particulars of which are given in a pamphlet by Mr. Cantelo.

SKETCH OF PATENT INCUBATOR.



A, B, C, D.—Cistern containing hot water, heated by an upright self-feeding stove; the top of which is seen at F, and the temperature of which is regulated by means of a slide in the lid.

G, H, I, J.—The glass ov-r which the water flows, and beneath which the eggs are placed on a tray, so constructed, like a spring sofa, to bring all the eggs in contact with the glass. The tray is lowered and raised by levers, which we have not shown in the sketch.

K, L.—Small cistern which receives the water after it has passed over the glass, and which conveys it to the pipes,

M, N, O, P, Q.—Through which the water returns to the cistern, to be again heated and perform the same circuit as before.

1, 2, 3, 4.—A drying nest in which the chickens are put for 12 or 24 hours.

Management of the Chickens.—Chickens, for the first 24 hours of their existence, do not require food. During this time they are supported by a large portion of the yolk, which, previous to their breaking the shell, had not entered their system. We need not therefore be in a hurry in removing the chickens from the hatching-nest: warmth is what they most require.

The best food, in my opinion, for young chickens is a paste made of three parts of oatmeal and one of barleymeal or bread-crumbs. The paste may be mixed with a light-boiled egg or fresh meat. They should, if the weather be fine, be turned out on the second or third day. Dampness is very injurious: care

should therefore be taken not to turn them out when there is any dew on the grass.

I have almost omitted to state that water must be given them in very shallow vessels. Curds made fresh every day are a very excellent thing, and are eagerly taken.

Chickens with the diet we recommend, and with the addition of a boiled potato, and the privilege of pecking grass in the plot, and attention, will make surprising progress. Attention is the great secret in the art of rearing chickens: too much food should never be given to them at once. We will dismiss this part of our subject by a quotation from Tusser:—

> " Tend such as we have,
> Young children and chickens would ever be eating."

At what Age should the Chickens be deprived of their Nurse?—On this subject little can be said, much depending on the discretion of the person in charge. Some chickens can forage for themselves when 5 weeks old, while others require maternal care till they are 8 or 9 weeks old. I should say, with the advantage of a good house and plot such as I have recommended, that the hen may be taken from them at the end of 6 weeks.

The chickens must remain in the plot 3 or 4 weeks longer: in it they are less exposed to accidents than if they were allowed to mix with the other stock.

The Turkey.—We may be allowed to observe that America is the native country of the turkey. By whom or at what period it was brought to England we have no proof. It must be upwards of 300 years since its introduction, as Tusser, in his 'Five Hundred Points of Good Husbandry,' published in 1573, speaks of the turkey as being extensively bred. The late H. D. Richardson, after duly investigating the subject, came to the conclusion that it must have made its appearance in this country about 1530.

Writers on poultry invariably give a long account of the natural habits of the turkey in its native wilds. All very good; but surely it has been long enough domesticated to enable the man who, as he jogs along the path of life, notes down his observations on the instincts, habits, and usefulness of the animals that daily attend him, to give plain directions for its management, without having recourse to its habits before it had been brought under subjection.

The only difference in the varieties of turkeys (the Norfolk excepted) is in colour.

The Norfolk variety (the produce of a cross with the wild American breed) is the largest. This at once testifies the advantage of procuring "fresh blood," and the ill effects of breeding

"in and in." The colour of this variety is black, and its weight ranges between 18 and 30 lbs. Some have been known to attain to the enormous weight of 56 lbs. Its flesh is allowed to be superior to that of any other breed, yet I have known cooks of considerable standing give decided preference to the white.

The white variety is not so easily reared, and never gets to the size of the Norfolk.

The copper coloured is very scarce, and is more difficult to rear than any other.

It would, in a country where the turkey is so abundantly reared and so highly esteemed—bringing with it, as Soyer says, "the joyous recollection of Christmas and an alderman in chains"—be superfluous to give a description of its appearance. Nor do we think it necessary to give instructions for the selection of stock from the same variety. There are but few men who cannot decide as to which is the handsomer of two birds, when standing side by side.

The form of animals which is ever most pleasing to the eye is almost invariably that form which denotes health. This is our maxim; and, from it, we contend that the only perfect plan of attaining a correct knowledge of the figures of animals is by comparing those of the same class with each other. Such a knowledge it would be impossible to get from books. This will sufficiently explain why I have not given instructions, as is the custom, "to enable our readers to distinguish between the handsome and the ugly."

There is great difference of opinion respecting the age when turkeys are in their prime, and how long they continue profitable. I consider the cock to be at his prime at three years, and the hen at two years old: whether they should be continued to breed from after these ages depends on the discretion of the owner. Some cocks are famous for being the sires of a healthy offspring, and so are some hens for being good sitters and nurses. To dispose of such, before symptoms of declining constitution are displayed in the health and number of the chicks, would display a want of judgment.

One fecundation is sufficient to render all the eggs fertile which are of one laying. This has been strongly denied by some. In this district many people keep hens only, and have to send them to some neighbour's cock: the hen is sent once only, yet it is known that nothing more is generally required to ensure the fertility of all the eggs of that laying.

The number of hens to one cock should not exceed fifteen.

From a change in the appearance and manner of the hen, the poultry-keeper is aware of her wants; and if not in possession of

a cock, proceeds as I have stated above. This takes place in February, March, or April. About a fortnight from this date (Feb. 26) one of our turkeys commenced to lay.

Some turkeys lay every day; some lay two days, and miss the third; while others lay only every other day.

The turkey-cock, in a state of nature, is ever seeking to destroy the eggs of the hen; and she, to delude him, seeks some secluded place in which to make her nest. In a domestic state, they in a great measure still retain the same propensities; it is therefore necessary to examine the hens every morning during the laying season, and keep in those that have to lay that day. If the hens be allowed to seek nests for themselves, the eggs are very frequently destroyed by magpies, rats, weasels, &c., or are lost.

The number of eggs laid by the turkey at one laying varies from twelve to twenty—most generally sixteen or seventeen; a number quite sufficient to be securely covered.

The eggs should be taken from the nest every day as soon as convenient, and placed in a vessel containing bran, or some other bad conductor of heat. We have not tried crushed charcoal, but we think it would answer very well.

The desire a turkey displays to sit is known by her remaining on the nest. It is not desirable that she should have the eggs immediately given to her; it is best to test her constancy for two or three days, at the end of which, should she prove true, they must be given to her—care being taken to have the eggs, if they be not all her own, near of the same age. To accomplish this, the eggs should have the date on which they were laid marked on them with a pencil.

The management should be such as to prevent other hens from laying in the nests occupied by those sitting; but as "accidents do occur in the best-regulated families," the eggs with which the turkey or other fowl is set should be marked to distinguish them from those which may afterwards be laid.

Some people recommend the setting of two turkeys at the same time, so as to be able to give both broods to one hen, that the other may again be at liberty to commence laying, and of course a second brood is got much sooner. On this mode of proceeding I offer no opinion.

So closely does the turkey-hen sit during the time of incubation, that very frequently she has to be forced off the nest. This must be daily attended to, otherwise, from want of food, she will get much reduced. We need not insist on the necessity of abundant feeding. The turkey is rather an absent bird, and so much does she enjoy herself when from her nest, that she often forgets to return to it in due time. The poultry-keeper must see to this,

and never allow her to remain off more than 20 minutes, unless the weather be very fine, when she may have the indulgence of a few extra minutes. We will not admit of any further interference; no one save the person in charge should be allowed to come near.

Mr. Richardson has stated, as has also the writer on poultry in Knight's Farmers' Cyclopædia, that the turkey-chick leaves the shell on the 31st day of incubation. This does not agree with my experience, as I have not found 31 days necessary. On referring to my note-book I find that one of our turkeys had 12 eggs given to her on Monday May 7, 1849. On Sunday morning, June 3, 11 fine strong chicks were found beneath her: the time she had sat was not quite 27 days; the weather during the time was very warm, which would of course have the effect of bringing the chicks a little sooner out. Nevertheless I cannot agree with Mr. Richardson and others, who state that the time of incubation of the turkey is 31 days; instances of such a long time must be very rare indeed, and I should look on them as omens of bad success. The number of eggs laid by the turkey I have named was few; but I must state that she was of a second brood, hatched the previous year, and consequently was very young. This fact proves the fallacy of the assertion that the females of a second brood should not be allowed to sit.

Should some of the turkey chicks be slower in freeing themselves from the shell than others, the same caution I have insisted on as in the case of fowls will be necessary. And I again point out the impropriety of interference, as the result will, in almost every instance, be in favour of allowing nature to have her sway. However, should it be found actually necessary to give assistance to some, the directions given under this head on fowls are amply sufficient. Many recommend the removal of the chicks from the nest as they come out—I highly disapprove of the plan; however, some people are so anxious to know the issue that no argument is sufficient to induce them to "let well be well:" such, therefore, may remove the chicks and put them in some warm place, as the mother from being so much disturbed is apt, at this critical juncture, to trample them to death.

The Food and Management of the Turkey Chicks.—The turkey chicks should not have food forced on them, at least not in the manner some do, by forcing them to swallow it. A drop of milk or water is of great service to them, and should be given by dipping the finger into the liquid and then putting the drop on to the beak: this is better than dipping the beak into the milk or water, as it prevents the chick from getting wet—a thing to be scrupulously avoided.

The turkey chick is much more stupid than that of the fowl;

the latter soon pecks with facility: on this account it is very recommendable to have two or three of them in every brood of the former, so that they, by force of example, learn to peck much sooner. This is accomplished by placing two or three fowl's eggs beneath the turkey at the end of the seventh day of incubation. The food we have found answer best consists of equal portions of oatmeal and the crumbs of white bread, mixed with a little boiling water, a light-boiled egg, and a considerable quantity of the leaves of the dandelion chopped small. This mixture should be given very frequently in small quantities on a clean floor. The reason why we have recommended the leaves of the dandelion before parsley, nettles, &c., is conclusive. A person I had in my service (with abilities and acquirements far beyond her sphere) had observed that turkeys when running about always devoured with avidity the leaves of this plant; and she, accordingly, determined to try the experiment of mixing it with the food for the turkey chicks, and such was her success, that during the whole time (5 years) she was with us she never lost one chick. And, moreover, when they were disposed of, they were not only equal but superior to all others in the market. This person being a great economist, always restricted herself to two eggs for one brood. She was also most assiduous in her duties, never allowing them to be exposed to a single drop of rain if it were possible to prevent it, until she was pretty certain they were old enough to bear it. About twice a week she gave them buttermilk to drink (always giving it them in very shallow vessels); at other times she gave them water or curds, than which nothing can be better. They should be made fresh every day. She gradually discontinued the use of oatmeal and the crumbs by substituting for them, at first, a small quantity of barley-meal, and increasing it until the chicks were eight or nine weeks old, at which age the oatmeal was left off. A boiled potato, moderately warm, should occasionally be given.

Undoubtedly the greatest obstacle to the profitable rearing of turkeys in our climate is dampness. It is therefore of the utmost importance to have the house in which they are kept thoroughly dry—never allow them to go out when it rains, or when there is any dew;—these rules must be strictly enforced until the chicks are nine or ten weeks old, at which age their backs will be found sufficiently well covered with feathers to withstand a shower of rain; still at this age they should not be too much exposed. Intense sunshine should all this time be guarded against.

Some turkey cocks trample the chicks to death, while others are proud of their young offspring; it is therefore necessary to watch the movements of the cock when first introduced to his family, and should a want of paternal affection be displayed he must be

punished, as he justly deserves, with confinement or banishment. We have waited until we have shown the opposite propensities displayed by different turkey cocks in a state of domestication, before we have taken into consideration the situation of the hatching nests. Should the turkey cock not be ill disposed, then the nests may be made in the turkey-house, while he is allowed to roost in it as usual; but should his character not be of the best sort, then he must be either excluded from the house or the nests must be made in some other situation. So much depends on the construction of the buildings that it is very difficult to give an opinion suitable to all circumstances. Should the turkey-house not be perfectly free from dampness, then it will be best to have the nests in that apartment of the fowl-house occupied by the breeding-fowls; but should the turkey-house be all that can be desired, then I would either advise the exclusion of the cock or the dividing of the house into two parts similar to the fowl-house. I must here repeat my conviction of the necessity of having the hatching-nests in the apartment in which are the laying-nests.

The Pea-fowl.—The pea-fowl is, in its habits, so very similar to the turkey, that the directions for the management of the one will suffice for the management of the other. We therefore think that we would not be justified in lengthening our essay by entering into details.

Nor do I feel a description of its appearance necessary, as its beauty and elegance are not only allowed but appreciated by all.

Since it is so very seldom sent to table, and so very unprolific, we look upon it as only an ornamental bird, more adapted for the pleasure-ground than for the farm-yard.

At the commencement of the laying season the peahen makes the advances, a peculiarity we could not pass over.

The Guinea-fowl.—The guinea-fowl, like the turkey and pea-fowl, is of a roving disposition, and requires much the same management.

On account of its not standing high as a sitter and mother, the common fowl is very frequently employed to hatch its eggs. The young are very tender, and should receive similar attention and should have the same sort of diet as the turkey chicks.

It is not my province to enter into the subject of "which is the most profitable sort of poultry?" yet I may be allowed to say that I do not consider the guinea-fowl so profitable as the common fowl. The eggs, although of good quality, are too far below the standard size for the market.

I acknowledge that the guinea-fowl, at the end of the game season, brings a good price, but may this not be attributed to its great scarcity in comparison with other poultry? A fact which would warrant the assumption of its unprofitableness.

The guinea-fowl, not only from its pugnacity but also from its habit of laying from home, is exceedingly troublesome; in some situations it would be imprudent to keep it. It is also very difficult to prevent it from flying into the garden, where it is very destructive.

In appearance it is considerably larger than the common fowl, but after the feathers are taken off there is very little difference.

Geese.—The management of geese is attended with less trouble than any other poultry (of course we mean in situations adapted for them); its food is of the very coarsest kind; I hesitate not, therefore, to affirm that the profit arising from them is immense.

We must, in the first place, attempt to set aside the prejudice which both ancient and modern writers have displayed against those which are parti-coloured. In the neighbourhood surrounding us large numbers are reared every year; we therefore have many opportunities of judging of the various qualities of the different colours to warrant us to come to conclusions without following in the path of compilers. I would as soon breed from a parti-coloured goose as from one all of the same colour. We had a grey and white goose which for successive seasons had two broods; the first never falling short of twelve (a number not one goose in twenty produces), and generally five, six, or seven, the second brood.

Geese are kept not for the production of eggs for sale, but for the purpose of hatching; the number of geese to one gander should not therefore exceed four. It is said, and strongly insisted on, if the goose be not in water when receiving proofs of the attachment of her male companion, that the eggs will not be fertile; we cannot speak to this, never having tried the experiment of keeping them from the water; however, it is received as a fact, and some go so far as to drive the goose to the water with her mate as soon as she leaves the nest.

The goose commences to lay in February or March, and continues until she has from 8 to 14 eggs. Some writers assert that, by removing the eggs from the nest as fast as they are laid, she may be induced to lay as far as 50, if highly fed. This appears to me very marvellous, for I never succeed in getting more than 12 or 13 from one goose. The eggs are removed as soon as the goose leaves the nest; and I think it impossible for geese to be better fed than ours.

The approach of the laying season is known by the goose picking up and throwing about her straws or small sticks or by picking lime off walls. As soon as this is observed, a nest should be provided for her in the same house in which she has to sit. Every morning she must be examined; when she has to lay she must be kept in, and if possible compelled to lay in the

nest provided for her; having once laid in it, she will seldom seek any other.

When the goose is inclined to hatch she remains on the nest; during the first two or three days she seldom sits steadily, the eggs should not therefore be given to her until the third day. The time of incubation is about 29 days. With geese, as with all poultry, during the time they are sitting the less they are interfered with the better. When the goose leaves her nest, care must be taken to supply a sufficient quantity of food and water, and that she does not remain too long from her eggs—say 15 minutes.

Goslings, being much hardier than the young of any other poultry, do not require so much caution in assisting such as make slow progress out of the shell.

If the weather be fine, the goslings should be turned out into a sheltered situation the first day after being hatched; however, at this season the weather is not always so charming, and I may mention that we had a brood that came out a few years ago during a time when the ground was thickly covered with snow. The snow remained on the ground a fortnight, and I was obliged to keep the goslings in the house during the whole time. Grass, being an indispensable part of the food of goslings, we were necessitated to procure for them pieces of turf. For the first few days goslings should have porridge, potatoes boiled and given when moderately warm, bread-crumbs, or curds; and should not have liberty to swim in water; this restriction should be gradually dispensed with. When seven or eight days old no further care is necessary (unless in bad weather) beyond giving them food.

I cannot agree with those who say that "the rankest, coarsest grasses constitute the goose's delicacy." Turn geese into a pasture of various qualities of grass, and they will soon show to which they give preference. I am not assuming, but write from having observed that they are fondest of the sweetest grasses. I have also observed them "waggling" through long grass and drawing the heads of the grass through their bills in order to procure the seed. The manner they turn their heads to one side to do this is very amusing. How coarse soever grass may be, geese will eat it, but to keep them well they must have an allowance once a-day of something more substantial. A mixture of boiled potatoes will answer the purpose; but by comparing the prices of these with the prices of oats, and by taking the nutritious properties of both into consideration, we shall find that the latter are at present prices considerably cheaper.

It is the custom in some parts to take a portion of the feathers off the geese two or three times a year—a custom I strongly

condemn; for, no later than last year, a party of whom I purchased a flock took advantage before delivering them of robbing them of a great part of their feathers; the consequence of which was the loss of the most of them. I admit a small quantity may be taken off with little or no injury; but then so few people can be trusted to do the work, that it is undoubtedly the best policy to let the feathers hang as they grow.

I have almost forgot to state that when geese get a habit of going through fences, the best way to prevent them is to hang a stick about 30 inches long across the breasts of the leaders.

Ducks.—In almost every rural situation ducks can be profitably kept. They lay abundantly, although at a season when the eggs of fowls are very plentiful, yet their eggs command a ready market from their known superiority for pastry purposes. Ducks acquire fat very fast, and their food being nothing more, if we may so speak, than refuse, they are hence not only profitable as layers, but also for the market.

The number of ducks to one drake should never exceed six, if the object be to have eggs for incubation. But if the eggs are for sale alone, then the number of ducks may be doubled.

I have before stated that the duck-house must be kept thoroughly clean; if this be attended to there is little difficulty in getting the ducks to lay constantly in it; but should it be, as we too often see, a house of filth, then there need be no surprise at the duck endeavouring to delude her keeper by seeking nests in obscure places.

The duck delights so much to be in water that she leads her brood to it when too young, especially at the commencement of the season, when the weather is frequently cold; she does not, therefore, stand high as a nurse, in consequence of which the incubation of duck-eggs is almost invariably intrusted to the hen of the fowl.

It very frequently happens that not a single duckling is obtained from a setting of eggs; a circumstance that can only be attributed to a want of fecundation: when such is the case the sooner another drake is obtained the better, to displace him that has too long had dominion.

The ducklings should make their appearance about the 29th day of incubation. Their management must be much the same as that described for goslings.

A custom prevails, which I have not seen noticed by authors, of cutting away with a pair of scissors the down on that part of the rump which will be occupied by the tail feathers. The reason given is that the weight of the hinder parts counterbalances the fore parts, and prevents the duckling from walking with

freedom. I have not tried the correctness of this assertion, and therefore cannot give an opinion: the ducklings of the wild varieties cannot have this operation performed on them, yet I will not say, in the face of a practice which in this district is universally adopted, that the ducklings are not benefited by it.

As I have said, the hatching of ducks is most frequently performed by the hen of the fowl. The hen, unconscious of the habits of her young charge, and having such an aversion to even dip her foot in water, must feel all the alarm she displays when first she sees her family plunge into an element so foreign to her nature. How often do we witness the parent in the deepest misery when the young are waddling in the mud in the height of enjoyment.

The Swan.—The swan is now seldom to be seen excepting in the parks of the very wealthiest classes, by whom it is kept as an ornament; we therefore do not feel ourselves justified in classing it with domestic poultry.

The Pigeon.—Pigeons ought, perhaps, from their being so extensively kept by many agriculturists, to receive a little attention in this paper. I keep pigeons, and have no hesitation in pronouncing them unprofitable; they, however, display so much character that I delight to see them.

The attention they require is very trifling, as they generally manage to rob as much food as they require from the poultry. When kept in great numbers the damage they do to the surrounding fields is immense. I may state that I have on several occasions known them do irreparable mischief to new-sown turnips. When they once get to the seed, their acute vision enables them to peck it with such destructive speed, as they pass along each "drill" or "stitch," that there seldom remains sufficient for a crop.

In some situations where they are sold for shooting matches, and the sportsmen are not "crack shots," I believe money may be made of them; for such as escape the deadly aim are almost certain to return to their old quarters, again to be sold, and perchance to return as before.

The house in which they are kept should have numerous small recesses in the wall, or be fitted up with wood-work to answer the same purpose. The old take care of the young until they are generally able to forage for themselves.

How to obtain a good Stock of Poultry.—Having treated on the various kinds of fowls in a manner which will, I hope, be of service in determining the variety best adapted to the district in which it has to be kept, I deem it my duty, in order to prevent disappointment, to add, that it is of the greatest importance to be in possession of such information as will enable the pur-

chaser to guard against imposition. As a large profit is principally kept in view by most poultry-dealers, their recommendations cannot in most cases be relied on. I therefore strongly recommend poultry-breeders to make their purchase of the poultry from which their stock is intended to be raised by the aid of a friend on whose veracity and judgment they can confidently depend.

I also advise not to purchase of a dealer without inspecting the birds, and knowing that the stock from which they have been obtained is pure. And as confinement is detrimental to the health of poultry, to guard against such as have been kept in coops.

Limit of Numbers of Poultry in proportion to the size of the Farm.—To what better purpose can a farmer apply a great part of his produce (especially at present prices) than in feeding poultry?

From calculations I have made of the value and quantity of food consumed, and the number of eggs laid, by fowls of the Dutch every-day laying variety, I am enabled to state that a profit of 150 per cent. may be realised. With such a startling fact before us, could I recommend the limiting of the number of fowls (of this breed) "in proportion to the size of the farm?" I am of opinion, if some part of the oat and barley crop which is carried to market were consumed on the farm by poultry, that it would be of great national benefit, by not only increasing the profits of the farmer, but by increasing the fertility of the soil by a greater supply of manure. It is true the prices of poultry and eggs may be so reduced as to be unremunerative; but such prices I do not anticipate.

Fowls are more profitable than turkeys, and the latter more than guinea-fowls; the proportion of fowls should therefore be decidedly the greatest. In fact, were it not that one likes to see the farm-yard stocked with every variety of poultry, I would recommend nothing but fowls and ducks.

Geese, as a breeding stock, are only adapted to some situations. The turkey and guinea-fowl, from the injury they do to standing crops of grain, are in some situations exceedingly troublesome.

On an arable farm of 200 acres there should not be fewer than 100 fowls, as many more as convenient, 3 turkeys, 3 guinea-fowls, and 12 ducks, as a standing stock. After harvest 100 geese should be bought to put into the stubble fields.

From the rules of competition which we have to-day (Feb. 27th) received we perceive that "in all reports of experiments the expenses shall be accurately detailed"—a thing we have not done when we stated that 150 per cent. may be realized by keeping fowls of the Dutch every-day laying breed. I now beg to state the value of food consumed, and the number of eggs produced.

The following is the weekly consumption of food, and the average produce of eggs, of four hens of the Dutch every-day laying variety:—

	s.	*d.*
1·4 gallons of barley at 20*s.* per quarter . . .	0	6
26 eggs at 1*s.* per score	1	3·6
Profit	0	9·6

—being upwards of 150 per cent. The consumption of food in this case is very great, being $1\frac{1}{2}d.$ each per week. We are at present trying experiments with the Spanish breed; we find that three hens and a cock consume in a week

	d.
½ gallon of oats at 14*s.* per quarter	1·3125
½ stone of barley-meal at 8*d.* per stone . .	4·
	5·3125

or rather more than $1\frac{1}{4}d.$ each per week. If the fowls had a free range we would calculate on keeping them on one-fourth of this amount.

Different kinds of Food.—The principal food of poultry, more especially fowls, turkeys, and the guinea-fowl, consists of grain, grass, and vegetables of the garden, including potatoes and turnips, and also of oatmeal, barley-meal, mill-sweepings, and pollen, made into a sort of thick porridge, and a variety of other things, such as oil-cake, broken meat, fish, animal offal (liquid or solid), liver, greaves, the refuse of the distiller, brewer, sugar refiner, and baker, the kernel of the coco-nut, &c. As not one farmer in five hundred can come at many of the things we have named, we must look to the direct produce of the farm for the supply of food.

Some recommend the grain to be boiled; but nature has so constructed the feathered tribe as to render this unnecessary; and as the nutritious property of the grain is not increased by boiling, no advantage is gained. (As a change we sometimes give it to fowls in coops.) Wheat, unless of the worst sort, is too valuable to be given to poultry. Rye is not much relished; in fact, after a few feeds, fowls will scarcely look at it.

Oats and barley are the best sorts of grain for the purpose of feeding poultry. Potatoes should be boiled or steamed (we give preference to the latter). Turnips must either be sliced or boiled, and mixed with pollen or barley-meal. Fowls are exceedingly fond of the young shoots of turnips, especially at the present season.

Feeding and Fattening.—I have reserved my remarks on feeding and fattening until I have described the rearing and management of all the varieties of poultry.

My reason for deviating from the usual method of giving directions for fattening at the end of the chapter on each variety is this, that there is so much similarity in the process of fattening that an unnecessary repetition would have been inevitable.

The quantity of food required to keep a standing stock of poultry (by this I mean all sorts not preparing for the market) depends vastly on circumstances. Where they have plenty of grass and a free range over a farm-yard, comparatively little "hand feeding" is required. They pick up in the yards and sheds occupied by cattle, pigs, &c., a great deal which would not only be wasted, but which would, if allowed to remain amongst the litter, be a perfect nuisance in the field. These should have a daily allowance during summer of oats, or barley, or other small grain, in the proportion of a handful to every four fowls or a gallon to one hundred. In winter they should have twice the quantity; the keeper must of course take the state of the weather into consideration.

Turkeys consume about twice as much as fowls.

Ducks should almost provide for themselves in the ditches, &c. I have almost forgot to state that there should, in winter, be a liberal supply of vegetables prepared in the manner recommended in the last chapter. They should also be indulged at times with a liver, given in such a quantity as they can consume in a day. It is taken for granted that all kitchen refuse will be given to them.

Many writers assert, that when fowls are so very highly fed they acquire fat to such an extent as to make them useless as layers, while on the other hand they say that the goose, if highly fed, may be induced to lay as many as 50 eggs. How are these two different statements to be reconciled with each other? For our part we believe them speculative. Fowls, and in fact all poultry, require an abundant supply of food. I am not an advocate of extreme proceedings, knowing that in all things a medium course leads to the happiest results. I look upon the fatness of the hen as I look upon the fatness of the cow—the effect and not the cause of non-laying and of non-milking. Regularity in the time of feeding is of the utmost importance.

Fattening.—Men of science tell us that it is utterly impossible to move one single muscle without a corresponding waste of the body taking place, and that an idea cannot enter into the brain without a corresponding change in the composition, and that warmth or heat is equivalent to a certain unknown amount of food. Need we therefore be surprised at finding the cock—the sprightly cock—shut up in a small coop to prevent muscular exertion, in darkness to prevent excitement, kept warm t economize food? all this that the poor bird may be loaded with

fat for the indulgence of man. But its measure of punishment is not yet filled—man must needs, to satisfy his cravings, cram food down the prisoner's throat. The very idea is revolting and "unfit for minds refined;" surely the poor animal should be permitted to obey the first law of nature. But stop: man, even not content with taking away the liberty of this noble bird and of cramming its food down its throat to gratify a vitiated appetite, goes yet deeper in the dye of cruelty, and half-bakes the living bird, as Soyer informs us, and for what? is it possible that it can be for nothing more than "increasing the size and delicacy of the liver!"

Cooping, by which the health is so materially affected, and to which many therefore so justly object, is rendered almost necessary, as cocks when allowed to mix with hens do not get to such heavy weights (especially when young) in consequence of the great attention they pay their fair companions, and from the many quarrels which, as a matter of course, must ensue between rivals.

This gallantry can be subdued by castration; this operation is performed when the cocks are about three months old, after which they receive the name of capons. Knowing that the only safe way of acquiring the art of castration is by seeing the operation performed, we decline giving directions, lest the bird be exposed to unnecessary cruelty by some attempting the operation who are unacquainted with its anatomy.

Pullets sometimes undergo a similar operation to destroy their reproductive powers, and are then termed poulardes. In our opinion this is not an economical mode of proceeding; instead of which, we would strongly recommend the disposal of the oldest hens. Old hens are not so profitable as young, and every year reduces their marketable value; and moreover, why not choose eggs for incubation which contain the male birds? The operation is more dangerous when performed on old birds.

Animals when castrated not only arrive at maturity considerably sooner even when intercourse is not allowed, but become larger and the flesh more delicate than when left entire. And had we only the arguments of analogical reasoning, we would unhesitatingly conclude that the advantage of castrating fowls (which are allowed to mingle with each other) is greatly in favour of the feeder; but argument is not required, the fact of the advantage is established, and I am surprised at the art not being better known. Many people object to it on the score of cruelty: why not object to it in the horse, the ox, the sheep, and the pig? The operation is only momentary. Capons are sometimes cooped the same as other poultry.

Coops are made in various ways; that description which is best adapted for the feeder is made to scarcely admit its tenant to turn

round, the board on which the bird stands being only one-third part of the size of the bottom, leaving two vacancies of equal size, one before and the other behind. To prevent the accumulation of, and to admit of the excrements being taken away without disturbing the birds, the coops are raised about 12 inches from the floor; and as I so strongly object to the cruel practice of cramming, a small moveable trough, about 3 inches deep, extends across the front of the coop, and divided into four parts, one part for small gravel, one for milk or water, one for grain, and the other for porridge. The grain should consist of equal quantities of oats and barley or tail wheat. The trough should always contain the grain, gravel, and milk or water, but the porridge should be given in small quantities. Grease, fat, or suet, quickens the process of fattening very much when mixed with the porridge, but I object to it on account of the flavour imparted to the flesh. In the course of three weeks a sufficient degree of fatness is attained, provided the house be dark, warm, and quiet.

Turkeys should be so fed as to be ever ready for the spit. This is our practice, and we always procure the best prices in the market—not for them only, but for all sorts of poultry. It would be useless to say more. However, I should remark that many people after harvest turn the turkeys into the adjoining stubble fields, where they pick up a great deal which would be wasted. From the position of our farm-buildings we have not been able to do this, and therefore cannot give a decided opinion on the practice.

Geese can be made fat enough for the palate of most people without being cooped or crammed, but whoever chooses this mode of fattening is at liberty to do so. The greatest portion attain a sufficient degree of fatness with nothing more than what they pick up in the stubble fields; when there is nothing of consequence in the fields for them to get, then of course hand feeding must be resorted to. It matters little what sort of food they get so long as they have plenty of it. Let such food as is cheapest to accomplish the purpose be chosen. We have found barley-meal to answer well; of course we give them, at the same time, water in a vessel.

Ducks as well as geese are exceedingly voracious, and will eat almost anything—animal matter half decomposed, such as butcher's offal, fish, frogs, &c.; but these, imparting a disagreeable flavour to the flesh, should not be given or allowed to be taken: it is therefore necessary (to prevent them from getting such filth) to curtail their walks for about ten days before being wanted, and feed them on a clean diet. They do not fatten so well when allowed to swim in water.

Diseases of Poultry.—Judging from the many diseases and recipes for the cure of them, enumerated in works on poultry, it may be inferred that fowls are very liable to diseases, and that I should enumerate them also: but mine having suffered very little, I willingly acknowledge my ignorance in the science belonging to the diseases of poultry. I may state that I look upon disease in a great measure as unnatural, brought on by artificial living, and without attending to the simple wants of nature. Domestic fowls, in their native land, the climate of which, of many of them, is much warmer than that of these islands, roost in the *open*, and consequently *pure*, air. In consequence of their instincts not being impaired by domestication, they are more cautious in the selection of their food. They drink of the water of the crystal brook. The weak are driven back by the strong. We, therefore, beg to bring this essay to a conclusion by adding that beautiful maxim, which ought to be written in letters of gold above the threshold of every dwelling, that "PREVENTION IS BETTER THAN CURE," and that diseases may be expected amongst the poultry—

1st. If their houses be damp, cold, unclean, or badly ventilated.

2nd. If the food they eat do not closely approximate to that which they obtain in nature.

3rd. If the water they drink be stagnant, the drainage of the manure heaps, &c.

4th. If the strongest and handsomest be not bred from.

Healey Mill, Hexham.

ILLUSTRATIONS.

At the request of the Author, application was made to Mr. Nolan, of Dublin, for leave to make use of the wood-engravings contained in his work on Domestic Fowl and Game Birds, for the illustration of this Essay; when that gentleman, with great kindness and liberality, at once placed them at the disposal of the Society. The two additional engravings of the Cochin-China fowls were made expressly for this Essay, from original drawings furnished by the Author.

XII.—*On Nitrate of Soda as a Top-Dressing of Wheat.* By PH. PUSEY, M.P., Member of Royal Academy of Agriculture at Stockholm.

HAVING read* that some very good farmers in Norfolk make a practice of top-dressing their wheat in spring with nitrate of soda, I determined once more to try this salt, which, as the older members of our Society will remember, was once a very fashionable manure, but the use of which was discontinued by its advocates in consequence of its tendency to lay the corn and to produce

* Report of "*Times* Commissioner."

mildew. These two serious faults, it now appears, may be corrected by mixing with the nitrate a moderate quantity of common sea-salt—which, when used in heavy doses, destroys the life of grass—and may therefore be readily supposed to counteract the dangerous suddenness of vegetation that nitrate produces. Thus common salt may prevent mildew, and is known certainly, on some soils, to strengthen the straw. The nitrate was sown as directed at the rate of one cwt. per acre, mixed with one cwt. of common salt; but this quantity was not given at once, being divided as enjoined into two doses, applied at a fortnight's interval and in showery weather. It was so applied to a 10-acre piece of white wheat, a portion thereof being, however, passed over. The whole produce has been threshed out already, in order to test the effect; a portion was top-dressed, not with nitrate, but guano. The result is as follows—

	Bushels per Acre.	Increase in Bushels.	Cost of Dressing.	Value of Increased Produce.
			s.	s. d.
Undressed	21	..	..	..
Guano, 2 cwts.	24	3	20	15 0
Nitrate, 1 cwt., and salt, 1 cwt. .	25½	4½	17	22 6

The other trial was made on an 8-acre piece of red wheat following barley. The wheat had begun to appear very blue and spindling, notwithstanding a good coat of dung given it in the autumn, to make up for cross cropping. The improvement was immediate, and has stood the test of threshing, for the account is as follows. Two acres were threshed, one on each side adjoining the half acre in the middle on which no nitrate of soda was sown.

	Bushels per Acre.	Increase in Bushels.	Cost of Dressing.	Value per Acre of Increased Produce.	Profit per Acre.
			s.	s.	s.
Undressed . . .	$19\frac{2}{5}$	..	..	..	..
Nitrated . . .	$27\frac{4}{5}$	$8\frac{2}{5}$	17	42	25

The profit on this piece is certainly more than the value to rent of the land, which is a poor blowing sand. The theory of this action is now clearly established by Mr. Lawes's experiments, for nitrogen, whether as ammonia in guano or whether in a nitrate, is proved to be the food generally wanted by wheat. Mr. Way informs me that nitrogen is now rather cheapest in guano, but it does not appear to be so effective as a top-dressing, possibly because in guano it is volatile and not so in nitrate. Clearly as there is no limit to the beds of nitrate in the plains of Peru, it will be a great advantage if we can thus hope to deal with the most unfortunate monopoly of guano, for with a large demand

for nitrate there can be no reason why we should not obtain a cheaper supply.

As to the practical application of nitrate with salt, I speak with diffidence, but I should look to it more for curing defects in a crop arising from season or from poverty of soil than for raising a good crop to a very high figure upon good land. Indeed in looking over the experiments made 10 years ago, I find that nitrate sometimes does not act at all upon good land.

We all know, however, how apt wheat is to turn off from frosts or from wireworm in February, and I do not think it would be at all rash to say that nitrate, used with judgment in such cases as a cordial to the sick plant, would almost enable us to control this source of uncertainty in the yield, and raise 20 bushels to 28, as it did with me, at a very moderate cost certainly for an extra quarter of wheat.

Above all I think nitrate may be most valuable upon cold undrained clays, as we know it indeed to have been. I do not of course mean that any clays should remain undrained—but many are undrained, and for want of funds are likely long to remain so. It is an old practice on heavy undrained land to dress the chilled wheat near the furrows with pigeons' dung. The nitrate would act in the same manner. Our forefathers were limited in such applications by their very narrow supply of artificial manures containing nitrogen, doves' dung only, or soot. It is the feature of the last 10 years that wide beds of nitrate, and now of phosphates, whole pyramids too, one may say, of guano, have been laid open to us. Their practice, therefore, should widen in our hands as our resources have widened.

Pusey, August 21, 1851.

XIII.—*On Superphosphate of Lime: its Composition, and the Methods of Making and Using it.* By J. Thomas Way, Consulting Chemist to the Royal Agricultural Society of England.

Of the different kinds of artificial manures now in use in this country, guano and superphosphate of lime are undoubtedly the most important and most extensively employed. Of the former, more than 100,000 tons are annually consumed in England and Wales; and although it is impossible to form anything like a correct estimate of the extent to which the superphosphate of lime is manufactured, it is evident from the number of persons engaged in its production, and its extended and still extending application for the turnip crop, that the quantity annually con-

sumed by our farmers is very great. Ten years have not yet elapsed since this manure was first offered to the agricultural public, but a sufficient amount of success has attended its use to justify us in predicting that in a few years more superphosphate of lime, or something of the same nature, will become an article of general agricultural interest and importance.

In relation to both of these manures the question then naturally arises, What are they? What is or should be their composition in a state of perfection? How nearly does their *actual* condition approach to what it should be? And what is the average quality which the consumer has a right to look for in purchasing them?

It is known to the readers of the Journal that I have already published a paper on the subject of guano in a former Number (vol. x. part 1). In common with many others, I had frequently experienced the difficulty arising from having no standard to which the composition and consequent money value of any particular sample of guano could be referred. The differences between genuine samples of this manure were always understood to be very great, and it was next to impossible to say whether a manifest inferiority in any particular specimen was to be held to be accidental and due to some peculiarity in the formation of the deposit, or, on the other hand, to be considered as the result of fraud and adulteration. The examination of fully fifty samples of the most important variety, the Peruvian, collected during two years, sufficiently established the fact, that throughout that period the composition of the genuine importations varied only within very narrow limits. These limits being once defined, and the average character of guano determined, we possessed henceforth a standard of comparison to which we might confidently appeal in all cases of difficulty.

In the two years which have elapsed since those analyses were published, I have examined a further very large number of samples of guano, both from the cargoes as they reached this country, and from quantities which, in the regular way of trade, had passed into the hands of different consumers. Many of the latter have turned out, on the most conclusive evidence, to be grievously adulterated. Some few have been found to be naturally inferior, but by far the greater number have possessed the composition fixed by previous analysis as the average of the genuine manure.

Although, therefore, samples of guano may occasionally be met with that, without any adulteration, have an inferior composition and a correspondingly less value than the genuine importations, there is no doubt that these cases are rare, and that the purchaser of the manure has a right to expect that it shall come

up to the standard so fixed, and has fair ground of complaint if it should be inferior, whether that inferiority proceed from adulteration or otherwise.

But if we were in difficulties about guano—a substance which was simply imported in its natural state—the tampering with or altering which constituted an act of adulteration, how much less satisfactory must be the trade in superphosphate of lime, which has at present no definite or fixed composition, and which may be of better or worse quality, according to the integrity and skill or the cupidity and ignorance of the manufacturer—for it is to be remembered that the term superphosphate of lime, in its present application, does not refer to a pure chemical substance containing known proportions of different ingredients, but to very various products having little in common but the name.

At present, therefore, it rests entirely with the manufacturer to decide what shall be the composition of the substance which he sells under the name of superphosphate of lime; and so little judgment and knowledge is in some cases employed in its manufacture, that I have several times met with samples of the manure containing no portion whatever of the substance it was intended to supply. Even with the best intentions on the part of the maker there is some little difficulty in obtaining a good article, and any error in the substances employed or in the mode of mixing them may easily lead to a very unsatisfactory result.

My object in the present paper is to point out what superphosphate of lime is: to give the composition of all those substances which are or may be used in its manufacture; to furnish approximative formulæ for the use of each of them; and finally, by showing what actually *is*, to indicate *what should be* the average composition and value of a fair market sample of this manure.

By this course I may hope to benefit the farmer in two ways: by enabling those who wish to do so, to take advantage of the different materials available for the making of superphosphate for their own use, and by affording to the less informed maker who is honestly anxious to produce a good manure, that amount of acquaintance with the subject which shall ensure his success. In so doing, I do not think it necessary to enter into a history of the manure, or to refer to the practical results that have been obtained from its use, and I shall confine myself to the chemical part of the subject, and to the *principles* which are involved, fully satisfied if, by so doing, I am able to raise the standard of its general *manufacture* to the perfection at which the best makers have already arrived, and of its *use* to that of the most intelligent turnip growers of this country.

There are several compounds of phosphoric acid and lime known to chemists, but of these two only in any way concern us

at present: these are the neutral phosphate of lime, sometimes called "bone earth phosphate," because it forms the chief earthy constituents of bones; and the bi-phosphate, or, as it is otherwise named, the acid phosphate of lime.

The term bi-phosphate of lime will, in the present paper, always be employed in speaking of the true chemical substance, the term "superphosphate" being reserved for the commercial mixture sold under that name. It is to be borne in mind then that, in the remarks that immediately follow, we are speaking only of the true chemical compounds; the phosphate and bi-phosphate of lime, as we are practically acquainted with them, being always largely mixed with other substances, as will presently appear.

Pure neutral phosphate of lime consists in the 100 parts of—

Phosphoric Acid	$48\frac{1}{2}$
Lime	$51\frac{1}{2}$
	100

It is only very slightly soluble in water, but more so in water in which carbonic acid gas is dissolved, and also, it is said, in solution of common salt and some other salts. The ease with which any substance can dissolve in water or other solvents is very much influenced by its mechanical condition: and this for obvious reasons. The more finely we powder and break up a lump of rock-salt or of alum, the more readily will it dissolve in water. There is a greater amount of surface exposed to the solvent action of the water, and more effect produced in a given time. Sooner or later, however, the rock salt and the alum will dissolve whatever may be the size of the lumps. But in some substances known to chemists an alteration in the state of aggregation—in the subdivision of the particles—gives rise to altogether new and different chemical properties, at all events in reference to solubility. Phosphate of lime itself is one of these.

Phosphate of lime, as we shall presently have to explain more in detail, occurs in a mineral state, and one variety of this mineral phosphate is known to us in the form of the coprolites of the crag and green sand formations. Some of these coprolites are excessively hard, so much so as to take a good polish. We have no reason to believe that they have been subject to the action of heat, but have become solid as we see them by rolling over and over, probably under considerable pressure. By proper means these stones can be reduced to a very fine powder, so as to be entirely free from gritty feeling when rubbed between the fingers. Now any attempts to dissolve this coprolite powder in acetic acid (vinegar) would entirely fail: some small portion of the phosphate might, indeed, be, after a long time, found in solution, but the action at the best would be very inconsiderable.

But it is possible to dissolve the coprolite in muriatic acid, and the addition of any alkali to the acid liquid will cause a bulky precipitate, which is phosphate of lime, precisely the same in composition as it was before solution, but differing evidently in the bulky and light character it has acquired. *This precipitated phosphate is readily soluble in acetic acid.* I call special attention to this point, because upon it hinges the whole question of the manufacture of superphosphate of lime.

You may have the same chemical substance in two different mechanical states, which materially alter its relations to solvents.

Some kinds of aggregated phosphate of lime are insoluble in a weak acid like vinegar; on the contrary, when in a light, bulky, highly divided form, they become readily soluble in the same acid; and what is true of one solvent is relatively true of another —if by chemical action you bring the phosphate of lime into a condition in which it dissolves readily in any given weak acids which it did not before, it stands to reason that you in the same proportion increase its solubility in other acids of a similar character. And so it comes to pass, that the natural solvent in the soil—water impregnated with carbonic acid—will readily dissolve the precipitated phosphate, whilst it might have little or no influence on the original mineral. And it is to be observed that no mechanical powdering of the coprolite practically within our reach will accomplish the change of form which is so easily brought about by simple chemical means.

Bi-phosphate of Lime.—This combination of lime and phosphoric acid, which exists in well-made superphosphate of lime, is not met with naturally either in a state of purity or otherwise; it can only be prepared by artificial means. The acid or bi-phosphate of lime contains in 100 parts, according to the analysis of Berzelius—

Phosphoric Acid . . .	$71\frac{1}{2}$
Lime.	$28\frac{1}{2}$*
	100

Now, if we make a comparison of the composition of these two products we shall readily see that the bi-phosphate of lime contains much more phosphoric acid than the neutral phosphate—it may, indeed, be considered as a solution of neutral phosphate in phosphoric acid, just as we have spoken but now of a solution

* Experiments have been made in my own laboratory by digesting precipitated phosphate of lime in phosphoric acid until the acid liquid refused to dissolve any further portion, and the result has accorded very closely with the above numbers. We may safely believe therefore that when phosphoric acid acts freely upon phosphate of lime, in a proper state of subdivision, the liquid will contain a compound such as we have described.

of the phosphate in acetic acid. As the only difference between the neutral and bi-phosphate is in the relative proportion of its ingredients, there will manifestly be two methods by which we might set about converting the one into the other. Either we may add phosphoric acid, or we may take away lime.

The latter method is the only one practicable in a manufacturing sense, and it is accomplished in this way:—Phosphoric acid is what chemists call a weak acid, that is to say, it does not unite with alkalies and earths in so powerful a manner as some other acids. Sulphuric acid, on the contrary, is a very powerful acid, and is capable of depriving a weaker acid than itself of any base with which it may be united. If sulphuric acid be added to phosphate of lime it immediately lays hold of the whole or of a portion of the lime according to the quantity employed, and the phosphoric acid is either liberated or remains united with a smaller quantity of lime.

In order to make this part of the subject understood, it will be necessary to put a case.

Let us suppose that 100 parts or pounds of chemically pure phosphate of lime are taken. This quantity contains 48½ parts of phosphoric acid. The first point is to ascertain how much lime must be taken away to convert this neutral phosphate into superphosphate. It was seen before that 100 parts of pure bi-phosphate contain 71½ parts of phosphoric acid.

If, then, 71½ parts of phosphoric acid produce 100 of bi-phosphate, 48½ parts (or the quantity contained in 100 of the neutral phosphate) will be equal to 68 parts of bi-phosphate. In other words, 100 parts of neutral phosphate can be converted into 68 parts of the bi-phosphate: and this change is to be effected by the abstraction of 32 parts of lime.

If we have succeeded in making this plain, it will be seen that a given quantity of neutral phosphate is capable of furnishing a somewhat less quantity of superphosphate, and the difference between the first and the second is the quantity of lime to be removed. The next point to decide is the quantity of sulphuric acid to be employed for this purpose; and in speaking of this, I shall treat it quite irrespectively of the state in which the acid occurs in practice, and as if we were dealing with an absolutely pure and undiluted substance. The practical bearing of these laws will be discussed subsequently. 41½ parts of lime combine with 58½ parts of sulphuric acid to produce 100 parts of sulphate of lime. Now, to convert 100 parts of phosphate into superphosphate we have found that it is required to abstract or separate 32 parts of lime; and it will be found that these 32 parts to be separated will require 45 parts of acid.

So that the result of our calculations is, that for every 100

parts of absolute phosphate of lime, we must employ 45 parts of absolute sulphuric acid, and we shall obtain 68 parts of bi-phosphate of lime and 77 parts of sulphate of lime. But though we have spoken of abstracting or separating a certain quantity of lime from the phosphate, it is plain that this is only to be understood in a chemical sense; the bi-phosphate and the sulphate of lime remain together, and the product is a mixture of these two substances.

It is also plain, from what has already been said, that there is a definite quantity of acid required to convert a definite quantity of phosphate of lime into bi-phosphate—if less than this quantity is employed, some of the phosphate remains unacted on and unchanged—if *more* than enough is added, then the more powerful acid (the sulphuric) proceeds to take the lime from the bi-phosphate; and if the acid be used in great excess the products would eventually be a mixture of sulphate of lime with uncombined phosphoric acid, and a certain excess of sulphuric acid also uncombined.

I have before said that bi-phosphate of lime can be prepared by dissolving phosphate of lime in phosphoric acid. The substance so prepared is exceedingly soluble in water, but capable of being crystallized by evaporation: the solution of bi-phosphate of lime is acid; when brought in contact with lime, potash, or soda in the caustic state, or with the carbonates of these bases, a portion of the phosphoric acid is neutralised, and the phosphate of lime is precipitated and rendered insoluble. This point deserves great attention, for it explains what happens to the soluble phosphate of lime in the soil. We have before seen that we can convert the neutral and insoluble phosphates of lime into the bi-phosphate or soluble compound, by removing some of its lime, and conversely we can retransform this soluble phosphate into the insoluble condition by the addition of lime or its carbonate. But by so doing we do not recover the phosphate of lime in the same form; it is, indeed, still comparatively insoluble in water, but it is in the bulky subdivided state in which it is easily attacked by the weakest acids. These facts serve to explain the nature of the advantage which superphosphate of lime possesses over phosphate of lime that has not been treated with acids. It has been frequently supposed that the superphosphate of lime from its solubility passed as such directly into the roots of plants, but there is every reason to believe that this opinion is entirely erroneous. In the first place it is very unlikely that a substance, possessed of powerful acid properties, could enter, without injuring them, into the delicate roots of plants; and, in the second, it is clear that the superphosphate of lime, when it once becomes incorporated with and dissolved by the moisture of the soil, must meet with lime or other bases, and be speedily neutralized. If, indeed, the value of this substance

as a manure were in any measure dependent on its retaining its composition and remaining in this highly soluble condition in the soil, we could not expect to see its application productive of any good result on soils which contain even a moderate quantity of lime, much less on those of the chalk and limestone districts. Professor Liebig, who suggested the use of this manure in the first edition of his 'Chemistry of Agriculture,' says, in speaking of this point—"In a few seconds the free acids unite with the bases contained in the earth, and a neutral salt is formed in a very fine state of division." In some cases the neutralizing base may be potash or soda, and then an alkaline and highly soluble phosphate is formed, but the quantity of lime existing in most cultivated soils would tend to convert the soluble phosphate of lime wholly into neutral phosphate of the same base.

If the view now taken be correct, the sole advantage of adding sulphuric acid to any substance containing phosphate of lime is to produce a soluble compound, not for direct use of the plants, but which shall penetrate intimately a large portion of soil, and there reproduce the phosphate in a state of the finest subdivision, and more perfectly distributed throughout the particles of earth than it could be by any mechanical process.

There are two points to be attended to in relation to this part of our subject. The first is the *subdivision* (by chemical not mechanical means) of the phosphate of lime; the second, the *distribution* of this substance (also by chemical and not by mechanical means) through the soil. We will take a simple case for illustration. Suppose that we are desirous of converting a certain quantity of hard mineral phosphate of lime into a state in which it will be readily serviceable to vegetation, and let it be granted that although very finely powdered it is in its natural condition of little use as manure—to this powdered phosphate we add sulphuric acid, which converts, as we have before seen, the insoluble phosphate into bi-phosphate, the product being the well-known "superphosphate." Supposing further, that we divide this product into two portions—to the one we add lime or chalk, and then incorporate it with the soil, whilst the other is dissolved in water and so applied. In either case the same precipitated phosphate of lime is the *ultimate* result; but there is this great difference between the two experiments—that whilst the solution of bi-phosphate of lime distributes itself throughout the soil before it meets with lime to saturate and solidify it, the quantity that has been mixed with lime or chalk previous to use is already saturated and rendered insoluble, and is entirely dependent on mechanical processes for its perfect distribution through the soil. These facts are, I contend, of the highest importance both to the manufacturer and consumer of superphosphate. They are important to the

manufacturer, because, as I have reason to know in many instances that have come to my notice, he is apt to think that he has done his duty if he employs the prescribed quantities of phosphoric substances and acid to dissolve them, making it a matter of convenience to himself as to what he subsequently adds to dry up the mixture and render it portable and fit for use; and should he choose chalk for this purpose, which not unfrequently happens, it is clear that the consumer, whilst he has the advantage of *subdivision,* loses that of *distribution.* They are important to the consumer; inasmuch as attention to this point will preserve him from mixing the superphosphate with those substances which are likely to prevent its equal distribution through the soil. To this subject, however, we shall have occasion to recur hereafter.

Having now endeavoured at some length to show that the object of the manufacturer should be the production of a highly soluble phosphate of lime, and that the consumer should so employ it that the reconversion into the insoluble condition may take place only in the intimate recesses of the soil; and having further insisted upon the distinction between mere *subdivision* and *distribution,* the former of which is, in my opinion, only half complete without the latter, I shall pass on to describe very shortly the substances employed in the manufacture of superphosphate, and to show what circumstances should guide us in their use, leaving to a later part of the paper to offer any practical suggestions that may arise from a careful consideration of the various principles involved.

It is plain from what we have already said that superphosphate of lime may be made from sulphuric acid and any substance containing phosphate of lime. The substances that are or can be employed in the manufacture are—

- Bones, either boiled or raw,
- Bone ash,
- Bone or animal charcoal,
- Guano, especially the African variety,
- The so-called coprolites of the crag and chalk formations,
- And the phosphorite or mineral phosphate of Estremadura and the United States.

Some other substances are occasionally employed, not, indeed, as sources of phosphate of lime, but under the impression that they improve the manure, or because they are useful in drying it up and bringing it to a proper consistency. We shall take another opportunity of showing in what way they are employed.

I shall separately describe in as few words as possible the phosphoric substances above enumerated, and, after giving analyses of some of them, I shall point out what quantity of acid is

theoretically required to produce the most perfect manure, and what its composition would be when so made, it being of course understood that in practice it is not easy and not always desirable to attain this end. But before doing this it is necessary that I should say a few words of sulphuric acid itself. Sulphuric acid is known in commerce in two forms, both of which are solutions of the true acid in water, differing from each other only in their strength. Sulphuric acid, as it issues from the large leaden cisterns or "chambers" in which it is made, is not of the greatest strength which it is possible to attain. But this acid, which is known as "brown" or "chamber" acid, is very largely consumed for various manufacturing purposes. It can be concentrated by boiling it down in glass or platinum vessels, and is then called "oil of vitriol." The brown acid and oil of vitriol differ as before said in strength and also in density—the more the acid is concentrated the heavier it becomes. In its most concentrated form it is only, however, a solution of sulphuric acid—the real chemical compound sulphuric acid being unknown to commerce. In the remainder of this paper in speaking of *real sulphuric acid* I must be understood to mean the chemical substance, of which in oil of vitriol and chamber or brown acid we have only solutions of differing strengths. The strength of solutions of sulphuric acid is easily ascertained by finding their density, which can be done by any person by the aid of little glass balls or beads sold by the philosophical instrument makers; and as it is impossible to judge with any accuracy of the strength of the acid by its appearance, no person who attempts to make superphosphate of lime for sale, and indeed no farmer who makes it for his own use to any very considerable extent, should fail to take advantage of this simple means of ascertaining the strength and purity of the material which he is using. At the end of this paper I shall place a table constructed by Dr. Ure, which shows the quantity of real acid contained in solutions of sulphuric acid of different densities, and which will be found useful to those who may not have access to treatises on chemistry. By reference to this table it will be seen that the strongest oil of vitriol, of specific gravity (or density) 1·8485 (water being 1·000), contains in 100 parts $81\frac{1}{2}$ parts of real acid. The brown or chamber acid is much weaker and of course lighter—its density is usually from about 1·600 to 1·700, and every 100 parts, at 160 sp. gr., contain 58, and at 1·70 contain $64\frac{1}{2}$ parts of real acid. By the first column of the table we see that acid of this latter strength may be looked upon as a mixture of 79 parts of oil of vitriol and 21 parts of water.

These few remarks may perhaps suffice to enable us to calculate the quantity of either of these acids that it may be necessary

to add to any of the phosphoric substances which will come before us, and we now proceed to their description.

Bones—in the natural state—that is to say "raw" or unboiled—contain a certain quantity of moisture and fat, a large proportion of cartilage or gelatine and of phosphate of lime, with a smaller quantity of carbonate of the same base: small portions of magnesia and alkaline chlorides and sulphates are also found in bones, but in reference to our purpose they are wholly unimportant. The quantity of water, fat, and gelatine in bones varies in every different animals and in the same animals of different ages, so that it is impossible to give any analysis of them that shall apply to all cases. Our chief concern is with the phosphates and carbonates of lime, the quantity of which may be judged of with sufficient accuracy.

The following numbers will, I think, pretty well represent the composition of raw bones:—

Water, fat, and cartilage or gelatine	48
Phosphate of lime, with small quantities of phosphate of magnesia	46
Carbonate of lime	4
Alkaline chlorides and sulphates, &c.	2
	100

Of the first item we may allow perhaps 12 parts for water and 8 parts for fat, leaving the proportion of gelatine at 28 per cent.*

It is important that attention should now be called to the effect which carbonate of lime must have upon our calculations, whenever it occurs in company with the phosphate. The first action of the acid is upon the carbonate, the lime of which must be neutralized by sulphuric acid before the phosphate can be attacked; and in using those phosphoric materials which contain much carbonate of lime, such as the Suffolk coprolites, a great deal of waste must necessarily occur from this cause; and for the same reason the product will contain considerably more sulphate of lime than is accounted for by the action of the acid on the phosphate.

Every 100 parts of carbonate of lime require 80 parts of *real* sulphuric acid to convert them into sulphate of lime, and this quantity is contained in 98 parts of oil of vitriol and 124 parts of brown acid (sp. gr. 1·70). The carbonic acid is driven off in the process; and as this constitutes 44 parts of 100 of carbonate of lime, 56 of lime unite with the 80 parts of real acid to produce 136 parts of the sulphate: but sulphate of lime unites

* In a former paper I estimated the proportion of gelatine in raw bones at 33 per cent., and the nitrogen consequently supplied by them at 6 per cent. I have reason to think that this estimate was too high for *raw* bones, though it would apply with tolerable correctness to bones deprived of their water and fat.

with water to form gypsum, and the quantity of water with which 136 parts would combine is 35 parts; so that, in acting on 100 parts of carbonate of lime by sulphuric acid, we produce 171 parts of gypsum.

We proceed to calculate the theoretical quantity of acid to be applied to 100 lbs. of bones having the composition given in the analysis:—4 lbs. of carbonate of lime will neutralize about $3\frac{1}{4}$ lbs. of real acid, which is furnished in round numbers by 4 lbs. of oil of vitriol and by 5 lbs. of brown acid (sp. gr. 1·70). The product will be 6 lbs. of gypsum.

The acid next attacks the phosphates, which may practically be considered as consisting entirely of phosphate of lime. By calculations previously given (page 209), the 46 parts of phosphate of lime will be entirely converted into bi-phosphate by 25 lbs. of oil of vitriol or by 32 lbs. of acid of density 1·70.

It is to be understood that the phosphate and carbonate are the only substances in bones that serve to neutralize or use up the acid; for although sulphuric acid attacks gelatine and other animal matters, it does not do so to any considerable extent without heat, especially when diluted. Great heat is undoubtedly produced in the mixture of bones and acid, and the former are blackened by the combined action; but this very heat serves to accelerate the solution of the bones and to employ the acid to its legitimate purpose. I do not believe, therefore, that any considerable amount of acid is got rid of except by the carbonate and the phosphate.

100 lbs. of raw bones then require of oil of vitriol—

	lbs.
To neutralize the carbonate	4
To convert the whole phosphate into bi-phosphate .	25
	29

So far as we are in a position to judge, therefore, from chemical data, which in such a case are paramount, we are using abundance of acid when we employ oil of vitriol to the extent of 1-3rd of the weight of the raw bones; that is to say, always supposing that the bones are finely crushed, the acid sufficiently diluted, and the mixture well made.

I think the recommendation that has been made, and very commonly acted upon, of treating the bones with *one-half* their weight of oil of vitriol, is so far unfortunate that farmers have been thereby put to an unnecessary expense, for, as will presently appear, the acid is by far the most costly material in the manufacture. One-third of acid seems quite enough, especially when the farmer makes the superphosphate for his own use, because it is not important to him to decompose the whole of

the phosphate, which will eventually come into operation as a manure, although at a later period of the growth of the plant.

Neither does it appear that any slight error or understatement of the percentage of phosphate of lime in raw bones will make the difference to which we are calling attention. Knowing the composition of the bones and the quantity of acid employed, we may readily calculate what would be the composition of a mixture such as we have described after it had dried up to a given extent. My experience of superphosphate of lime, as it occurs in the market, would induce me to fix the proportion of moisture at about 10 per cent., and, if some specimens exceed this proportion, the greater number of well-made samples fall short of it. The mixture of 100 lbs. of raw bones and 29 lbs. of oil of vitriol would, after drying up, give a product having the following composition in 100 parts:—

Moisture	10	
Animal matter and fat . .	27	
Hydrated sulphate of lime (gypsum)	39	
Bi-phosphate of lime, soluble .	24	Equal to 35 parts of bone-earth phosphate rendered soluble.
	100	

The animal matter (gelatine), being about 21 per cent., would furnish $1\frac{1}{4}$ lb. of nitrogen, equal to rather more than $1\frac{1}{2}$ lb. of ammonia.

In the above statements no neutral or insoluble phosphate is mentioned, because it is supposed to be entirely converted into bi-phosphate. We must repeat that this is practically impossible; the manufacturer will either fall somewhat short of the entire decomposition of the phosphate, or he will go beyond it, setting phosphoric acid free, which to the consumer is by no means an objection. But it is certainly an object, especially when the phosphate employed is of mineral origin, to exceed rather than fall short of the mark, so as to leave none of the insoluble phosphate unacted on.

I pass on now to consider the manufacture of this manure from boiled bones, in which state probably by far the larger proportion of them are used.

When bones are boiled their fat is separated, and a good deal of the gelatine or glue is at the same time extracted. The fat separates pretty readily, but the bones require lengthened boiling to extract much of the gelatine. They will be more or less altered, therefore, according to the purpose with which they have been boiled. If the fat alone has been taken out, the only change necessary in the formula given for the raw bones

will be the use of (say) 1-10th part more acid, supposing the bones to be as dry as they were before the fat was removed. But, in point of fact, as the fat is separated, water takes its place, and practically we should be sufficiently near the truth if we employed the same quantity of acid to bones which have been boiled for their fat as to the raw bones. But the difference is considerable when much gelatine has been separated by the glue-maker. I give below an analysis, made in my laboratory, of boiled bones, from which the whole of the fat and a great deal of the gelatine have been separated.

Moisture	10
Animal matter, &c.	16
Sand	3
Phosphate of lime	60
Carbonate of lime	11
	100

This, no doubt, is an extreme case; the animal matter not being usually so much removed by boiling. The quantity of oil of vitriol required to convert the phosphate of 100 lbs. into bi-phosphate here will be—

For the carbonate	11 lbs.
For the phosphate	33 ,,
	44 ,,

The quantity of acid to be employed more nearly approximates to one-half than in the former case; but even here the use of one-third of acid would give a percentage of soluble phosphate much larger than we are accustomed to meet with in the best commercial samples. I shall give the composition of a superphosphate which would result from the mixture of 100 lbs. of the above boiled bones with 33 lbs. and 44 lbs. of oil of vitriol respectively:—

	With 33 lbs. of Oil of Vitriol.	With 44 lbs. of Oil of Vitriol.
Moisture	10	10
Animal matter	12	11
Sand, &c.	2	2
Hydrated sulphate of lime, gypsum	42	51
Bi-phosphate of lime	20	26
Neutral insoluble phosphate of lime	14	none
	100	100

The quantity of nitrogen in both these cases would be small, the animal matter being low in percentage. The first would give about 7-10ths per cent., equal to a little more than 8-10ths ammonia; and the second rather less.

Bone-ash and Bone-black or Animal Charcoal.—Bones, when

heated in an open furnace, are reduced to a white ash. I do not imagine that this is often done with the view of making superphosphate from the products, as, whilst nitrogen and ammonia have so high a value, it would be a very unwise and wasteful process; but I am given to understand that the bones of whales and other animals have been occasionally so burnt to render them lighter and more portable and prevent the danger arising from their heating in the holds of vessels in which they are to be brought to this country.

Bone-ash would contain on an average perhaps from 80 to 90 per cent. of phosphate, and from 8 to 12 per cent. of carbonate of lime. Animal charcoal is prepared by heating bones in close iron vessels, such as gas-retorts. It is used very largely by the sugar-refiners, and comes into the possession of the manure-maker only when it has ceased to be of any service to the former. When originally made, animal charcoal, or bone-black, contains a considerable percentage of charcoal, but after it has been burned over and over again, until it ceases to possess any discolouring power for the syrups of the sugar-boiler, the proportion of charcoal is very much reduced, and the phosphate proportionally increased. I have found the waste animal charcoal to contain from 65 to 75 per cent. of phosphate of lime, with 10 or 12 per cent. of carbonate, and about the same quantity of charcoal. But both this and bone-ash vary very much in quality, and in all cases it is necessary to ascertain their composition by analysis before employing them largely in the manufacture of superphosphate. They are seldom the basis of this manure, but only one of the ingredients.

Superphosphate of lime from coprolites.—The coprolites of the crag formation are obtained abundantly and cheaply, and have been extensively employed as a source of phosphoric acid in the manufacture of the superposphate. They are very hard, and are only attacked with any energy by sulphuric acid after they have been reduced to a fine powder.

The following numbers will represent approximatively the composition of these fossils; they are the results of an analysis made by me some time ago of a sample taken from a heap of the powdered coprolite:—

Water (of combination) and a little bituminous matter	10
Sand, clay, and oxide of iron	21
Carbonate of lime	10
Phosphate of lime	56
Fluoride of calcium, with small portions of alkaline sulphates and chlorides	3
	100

It is very possible that the composition of samples of ground

coprolite might, from a variety of circumstances, be found to vary from time to time, and the above statement is therefore only applicable as a general rule. It is said that the carbonate of lime in particular is sometimes in considerably larger proportion than that given above. In dissolving coprolite powder in sulphuric acid an escape of hydrofluoric acid takes place, and some of the sulphuric acid is neutralized by the lime of the fluoride of calcium. In the case of the coprolites it is needless, however, to complicate the matter by making allowance for this circumstance.

To convert the phosphate of lime of 100 lbs. of Suffolk coprolite entirely into bi-phosphate would require, of

Oil of vitriol, to neutralize the carbonate .	10 lbs.
For the phosphate	31 „
	41 „

The product, when dried up, would have something like the following composition in 100 parts:—

Moisture	10
Hydrated sulphate of lime (gypsum) . . .	49
Bi-phosphate of lime	25
Sand, clay, &c.	16
	100

In the above products there would not of course be any animal matter, as phosphate of lime is a purely mineral substance; but it is very seldom that a mixture of sulphuric acid and coprolites alone would be sold as superphosphate of lime, unless it were distinctly so stated. By conventional understanding the commercial "superphosphate" is a mixture of soluble phosphate with animal substances or ammoniacal salts—more or less resembling, in fact, the product that would result from the treatment of bones with acid.

The phosphoric fossils of the upper and lower greensand formations may of course, when obtainable in sufficient quantity, be substituted for those of the crag. It will be sufficient here to state that the fossils of the upper greensand contain from 55 to 60 per cent. of phosphate, and 8 to 10 of carbonate; and those of the lower greensand from 38 to 40 per cent. of phosphate, with little or no carbonate. This latter circumstance is of much advantage in the economy of the acid, and in spite of their lower percentage of phosphate they would furnish more soluble phosphate for a given expense than those of the crag or the upper greensand.

Superphosphate from the Phosphorite of Estremadura and the United States.—The phosphorite of Spain has not been imported

into this country to any considerable extent, in consequence of the great expense of getting it on board ship; at present, therefore, it is not likely to be of practical importance in the manufacture of superphosphate of lime.

Dr. Daubeny's analysis of this substance* is as follows:—

Silica	1·70
Peroxide of iron	3·15
Fluoride of calcium	14·00
Phosphate of lime	81·15
	100·00

In a small sample of this same deposit, presented to the Royal Agricultural Society by Mr. Kimberley, I found 41½ per cent. of phosphoric acid, equal to 85½ per cent. of bone-earth phosphate; so that this phosphorite is very rich in phosphoric acid. The Spanish mineral contains no carbonate; but Dr. Daubeny found in it 14 per cent. of fluoride of calcium, which, as we before mentioned, reduces the effective strength of the acid mixed with it. Every 100 parts of fluoride of calcium will saturate 103 parts of *real* sulphuric acid, or 120 of oil of vitriol; and allowance must be made for this circumstance in apportioning the acid to be employed. The American phosphorite has only been lately introduced to our notice. It is described as occurring in beds of considerable thickness, and extending over a large district of country, in the states of New York and New Jersey.

In a sample of this phosphorite from New Jersey I found 25·3 per cent. of phosphoric acid, equal to 52 per cent. of bone-earth phosphate, with a large proportion of fluoride of calcium, and 20 per cent. of quartz sand. I have also examined a sample from the state of New York, presented to the Society by Mr. B. P. Johnson, of New York. Many pounds of the material were broken up, so as to ensure an average result, which was as follows:—

Bituminous matter and water expelled at a red heat	0·69
Substances insoluble in acid, chiefly quartz sand	16·79
Silica (soluble in acids)	0·65
Phosphoric acid, equal to 62·27 bone-earth phosphate	30·20†
Lime	40·10

* Journal of the Royal Agricultural Society, vol. v., part ii., p. 414. Dr. Daubeny, however, expressly states, that the portion subjected to analysis was selected for its apparent purity and freedom from admixture with the less phosphoric materials of the rock, so that a *practical average* would probably give us a much lower percentage of phosphoric acid.

† The mean of four determinations made by different methods:—

1st determination gave	29·50	mean 30·20.
2nd ,, ,,	30·33	
3rd ,, ,,	29·77	
4th ,, ,,	31·23	

Peroxide of iron	6·47
Magnesia	1·08
Chloride of sodium	0·08
Soda	0·20
Potash	0·25
Sulphuric acid	trace.
Fluorine and loss in analysis	3·49
	100·00

A mineral phosphate of this composition will be of somewhat greater value as a source of phosphoric acid for superphosphate than the coprolites of the crag. I shall not, however, attempt to give a formula for its treatment by sulphuric acid, since it is quite likely that further experience in the working of the beds may lead to the discovery of continuous layers of a more uniform character, and less intermixed with quartz and other extraneous substances which reduce the proportion of phosphoric acid.

After all, the practical question is not what percentage of phosphate of lime is contained in a particular fragment of this or that mineral, but what will be its average proportion on tens and hundreds of tons; and this information can only be satisfactorily furnished after some considerable experience in the working of the deposits. It is also for our agriculturists and manufacturers of manure to remember that phosphoric acid and lime unite in several proportions, forming compounds, all of which would be included under the general head of "phosphate of lime;" but their value as sources of superphosphate depends upon the actual percentage of phosphoric acid and its relation to the quantity of lime—*bone-earth phosphate* being in all cases the standard of comparison.

Superphosphate from Guano.—Whilst a good supply of guano, rich in phosphate of lime, was to be met with in the market, this substance was frequently resorted to for the production of superphosphate. Saldanha Bay guano contains, on an average, 56 per cent., and Patagonian 44 per cent., of phosphate of lime, unmixed with any quantity of carbonate. Peruvian guano contains usually 24 per cent.: it has not, that I am aware, been employed in any quantity as the *basis* of superphosphate, but may with advantage be added to the manure as a source of nitrogen or ammonia. It would be well worth while also to try a mixture of Peruvian guano with oil of vitriol as a manure for turnips.

Substances employed as accessories to the manufacture of Superphosphate.—In treating any posphoric substances with sulphuric acid it is usual to employ so much water that the product is semi-fluid, or at all events so damp as to need the addition of some dry absorbent material to bring it to a proper consistency for use: the

substances so employed are animal charcoal, kelp, rape-cake, shoddy, &c. Animal charcoal is itself a source of phosphate of lime, and may consequently be added at any stage of the process. Kelp is a substance prepared from the ashes of sea-weeds, and contains a large proportion of alkaline carbonates; its value as an ingredient of superphosphate of lime appears to me questionable—inasmuch as, although a certain quantity of alkaline phosphate may result from its admixture with the soluble phosphate, much phosphate of lime is at the same time precipitated, and the effect of using kelp will be to reduce the total quantity of phosphoric acid in solution. Rape-cake and shoddy may be useful additions to a manure made from mineral phosphate only, but are not necessary in the case of superphosphate made from bones and acid only.

The sulphate and muriate of ammonia are also added occasionally to superphosphate of lime with advantage; the latter, however, by producing muriate of lime, causes the product to attract moisture, and renders it very difficult of transportation. Dried blood, which is becoming an article of considerable commerce, and which contains from 10 to 12 per cent. of nitrogen, forms also a good addition to a mineral superphosphate, both as a drying material and as supplying animal matter.

Composition of Commercial Superphosphate of Lime.—Such being the means at the disposal of the manufacturer, let us now see what is the nature of the manure as actually supplied to the farmer. During the last 2 or 3 years I have examined a very large number of samples sent to me, in some cases by the buyers, in others by the makers, of the manure. I shall select from these such a number of cases as will illustrate the question and will represent what, in my opinion, is the composition of a very bad, and what of a very good, sample of superphosphate; and, as a practical mean, the analysis of samples of fair average quality will be given, in proof that we are not without manure-dealers possessing both principle and intelligence enough to enable them to supply the agricultural public with a good article.

The annexed are analyses of some of the best samples of superphosphate of lime which have come under my notice.

The first of these samples contains the highest percentage of soluble phosphate that I have as yet met with—it is almost entirely a *mineral* superphosphate. Nos. 2 and 3 are excellent specimens of the manure, containing, in addition to a large proportion of soluble phosphate, a considerable amount of nitrogen; No. 4 is not so peculiar for its quantity of soluble phosphate as for the combination with it of a very high percentage of nitrogen.

Analyses of Superphosphate of Lime (Superior Samples).

——	No. 1.	No. 2.	No. 3.	No. 4.
Moisture	14·71	9·66	3·75	4·05
Organic matter and salts of ammonia	10·18	14·50	21·35	26·00
Bi-phosphate of lime (soluble)	18·50	15·34	15·45	9·92
Neutral phosphate (insoluble)	6·35	15·72	1·12	20·43
Sand, &c.	9·98	2·83	9·70	1·97
Hydrated sulphate of lime (gypsum)	36·63	36·12	40·04	31·29
Alkaline sulphates and muriates and substances undetermined	3·65	5·83	8·59	6·34
	100·00	100·00	100·00	100·00
Nitrogen in the organic matter and ammoniacal salts	Undetermined.	2·33	2·03	3·24
Neutral phosphate, to which the bi-phosphate is equal	27·20	22·62	22·78	14·62

At the foot of the tables I have placed a line indicating the amount of *precipitated phosphate* which will be formed by each sample when mixed with the soil. The numbers also indicate how much of the neutral phosphate has been acted on and rendered soluble. In comparison with these we will now take the analyses of some bad samples, of which, I regret to say, the number given is, relatively to those which have passed through my hands, very small.

Analyses of Superphosphate of Lime (Inferior Samples).

——	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.
Moisture	11·58	11·80	25·19	9·22	9·08
Organic matter and salts of ammonia	8·33	5·21	3·87	15·60	8·66
Bi-phosphate of lime (soluble)	1·61	2·58	4·74	3·41	2·90
Neutral phosphate (insoluble)	23·45	0·06	28·32	24·74	18·79
Sand, &c.	6·41	5·07	2·44	10·53	7·41
Hydrated sulphate of lime (gypsum)	26·64	74·98	35·44	36·50	50·08
Alkaline sulphates, muriates, and substance undetermined	21·68	0·37			3·08
	100·00	100·00	100·00	100·00	100·00
Nitrogen in the organic matter and salts of ammonia	Undetermined.	0·44	0·12	0·40	0·57
Neutral phosphate to which the bi-phosphate is equal	2·38	3·79	7·00	5·03	4·29

The sample No. 5 has evidently been mixed with kelp or

some similar material. Samples Nos. 7, 8, 9, owe their inferiority in great measure to the parsimonious use of the acid; but, in addition to this, they must either have been made from a material containing much carbonate, or gypsum must have been added to them. In No. 6 this latter fraud must undoubtedly have been practised: it is a mixture of a very small quantity of real superphosphate with sulphate of lime—the whole quantity of phosphate in any shape not reaching 3 per cent.

The following analyses show what an average sample may fairly be expected to reach. I by no means allow that they are so good as they ought to be, because it is easy to show that they can be made better at the present prices and with a fair remuneration to the maker.

Analyses of Superphosphate of Lime (Average Samples).

—	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.
Moisture	10·45	22·57	5·94	18·00	21·41
Organic matter and salts of ammonia	10·00	23·99	15·54	18·11	10·90
Bi-phosphate of lime (soluble)	12·40	10·78	10·38	8·32	8·09
Neutral phosphate (insoluble)	9·79	3·70	8·15	14·76	13·31
Sand, &c.	7·52	10·16	2·99	3·31	7·21
Hydrated sulphate of lime (gypsum)	49·84	17·68	57·00	37·50	39·08
Alkaline sulphates, muriates, and substances undetermined		11·12			
	100·00	100·00	100·00	100·00	100·00
Nitrogen	0·68	1·61	1·16	1·23	0·88
Neutral phosphate to which the bi-phosphate is equal	18·23	15·85	15·31	12·27	11·91

My experience leads me to believe that the farmer in buying superphosphate of lime has a right to expect that it shall contain *at the least* from 8 to 11 per cent. of bi-phosphate, which is equivalent to from 12 to 15 per cent. of the *neutral* phosphate, rendered soluble. He has a right also to expect that it should contain from ½ to 1½ per cent. of nitrogen, which is an indication of so much animal matter or ammoniacal salts being present, unless, indeed, he purchases a mineral superphosphate, knowing it to be such. Agricultural experience seems at the present time to lean to a judicious mixture of soluble phosphate with animal matters in preference to a purely mineral manure; but it must be remembered that this is not indispensable in cases where the land is in good condition, or where farm-yard manure is largely applied for the turnip crop: in these cases superphosphate is applied

mainly for the special influence that the soluble phosphate has in forcing the plant rapidly into rough leaf. If superphosphate is used for a special purpose and in conjunction with other ordinary manure, there would appear to be no good reason why it should not be perfectly efficacious, although it contain no particle of animal or vegetable matter whatever.

Of the loss sustained by the farmer in purchasing an inferior sample of phosphate of lime it would seem hardly necessary to speak, did we not know how little care or attention is bestowed on these matters. If there be any object in adding sulphuric acid to bones or other phosphoric substances, and if that object is the production of a soluble phosphate, it seems pretty clear that some of the samples mentioned are by many times more valuable than others. Not to take an extreme case, let us compare the sample No. 7 with an average sample, such as No. 12. Here we find that the soluble phosphate is double in the latter what it is in the former, whilst the quantity of nitrogen is as 10 to 1. If the former is worth 7*l.* per ton, which in all probability would be the price paid for it, the latter must be cheap at 10*l.* But I know that superphosphate, having the composition given for sample No. 10, can be prepared, and is prepared, and sold in large quantities, at 7*l.* per ton; and as it is reasonable to suppose that it remunerates the dealer at this price, it is not too much to expect that there should be a corresponding value in other samples sold at that price. In a former paper I attempted to fix the value of the ingredients of guano, and a similar attempt will now be made in reference to superphosphate, taking the sample No. 10 as a standard. It will be of some importance for our future guidance that we should gain an approximative notion of the money value of soluble phosphate of lime. To do so it will be only necessary to deduct the manurial value of the nitrogen (ammonia) of the *insoluble* phosphate and of the gypsum from that of the mixed manure, and we gain at once an approach to that of the bi-phosphate. The price of ammonia has been fixed at between 5*d.* and 6*d.* per lb. according as it is bought in one or other of the commercial articles which furnish it. Phosphate of lime, in the insoluble state, is worth about $\frac{3}{4}$*d.* per lb.

Gypsum in the precipitated form, as a refuse from the manufacture of stearine candles, tartaric acid, &c., can be bought in almost unlimited quantity at from 15*s.* to 20*s.* per ton; at the latter price it will be worth something more than 1-4th of a farthing per lb.

The value of these three substances in a ton of sample No. 10 will be as follows:—

	£.	s.	d.
Sulphate of lime 49·8 (say 50) per cent., half a ton at 20*s*.	0	10	0
Insoluble phosphate of lime (9·79 per cent.) 220 lbs. at $\frac{3}{4}$*d*.	0	13	9
Nitrogen ·68 per cent., equal to ·82 per cent. of ammonia, or $18\frac{1}{2}$ lbs., at 6*d*.	0	9	3
Making	£1	13	0

as the value of all the ingredients, with the exception of the bi-phosphate. Deduct this sum from 7*l*., and we have 5*l*. as the value of 280 lbs. of bi-phosphate of lime, or about $4\frac{1}{4}$*d*. per lb. This 280 lbs. of bi-phosphate represents, and will form in the soil, 408 lbs. of neutral phosphate in the *precipitated* or active state, which will therefore cost or be of the value of $2\frac{3}{4}$*d*. or nearly 3*d*. per lb.

These calculations are necessarily crude, and open to many sources of error; they must be received in a general sense only, and as approximations to the truth. If, however, they serve to give us a general notion of the worth of the substance in question, they will be most useful in their application to individual cases.

The sample No. 4 was placed amongst those of superior quality from its large percentage of nitrogen coupled with a fair proportion of soluble phosphate; in common with Nos. 2 and 3, it has evidently been made from bones and sulphuric acid only. It may be worth while to place its money-value in comparison with the more mineral superphosphate No. 10. It contains—

	£.	s.	d.
31·29 per cent. of gypsum, which in a ton amounts to 700 lbs., of the value of	0	6	3
20·43 per cent. of neutral phosphate amounts to 457 lbs., of the value of	1	8	7
3·24 per cent. of nitrogen, equal to 3·94 per cent. of ammonia, or 88 lbs. in the ton, value	2	4	0
9·92 per cent. of bi-phosphate, or 222 lbs., which, at $4\frac{1}{4}$*d*. per lb., has a value of	3	18	7
	£7	17	5

This sample, being made from bones and acid alone, would probably be sold at 8*l*. per ton, so that, in fixing the value of bi-phosphate of lime at $4\frac{1}{4}$*d*. per lb., we do not seem to have erred very greatly. It will occur, perhaps, to the reader that the insoluble phosphate of lime unacted on by the acid will have a different value according to the source from which it is derived; that when, for instance, the manure has been made from bones or African guano, the phosphate, although not actually soluble in water, will be much more readily available to vegetation than

the phosphate of powdered coprolite in the same circumstances. This is true; and in speaking of the practical methods of making superphosphate of lime, we shall shortly allude to the subject again, but it would be useless to attempt to give to our present arguments such a degree of refinement as this would introduce.

In comparison with the money-value of good samples of superphosphate, let us take that of one of the inferior samples, No. 9, for instance, which is not by any means the worst that we have met with. It will be as follows :—

	£.	s.	d.
Gypsum 50 per cent., or ½ a ton, at 20*s*. . . .	0	10	0
Nitrogen at ·57 per cent., equal to ammonia ·69, or 15½ lbs. in a ton, worth	0	7	
Insoluble phosphate, 18·79 per cent., amounting in a ton to 420 lbs., worth	1	6	3
Bi-phosphate, 2·90 per cent., amounting to 65 lbs. in the ton, which, at 4¼*d*., is worth	1	3	0
Giving	£3	7	0

as the total value of 1 ton of such a sample of superphosphate, which would be sold at 7*l*., if not more.

But I have no hesitation in saying that such a manure is not worth one-half what we have in charity given it credit for, because the farmer, in buying superphosphate, does not want gypsum or insoluble phosphate of lime. *The manure is bought mainly for its soluble phosphoric acid.* And by the proportion of this and the animal matter or ammonia, as indicated by the quantity of nitrogen, must we be guided in fixing its relative worth.

We have attempted to fix the market-price of soluble phosphate by reference to the actual cost of it in the superphosphate as supplied by intelligent makers. It may not be amiss now to inquire what may be the cost of the *materials* for the production of a fair sample of this manure.

By reference to page 217 the reader will find the composition of a sample of superphosphate, supposed to be made by treating boiled bones with 1-3rd of their weight of oil of vitriol. Although this quantity of acid is only sufficient for the decomposition of 2-3rds of the phosphate, the product would contain more soluble phosphate than any sample that has been described. Boiled bones are worth from 4*l*. 10*s*. to 5*l*. 10*s*. per ton, say 5*l*. Oil of vitriol is worth 10*l*. per ton, and brown acid about 5*l*. The latter is a cheaper source of real acid, but it will simplify matters to suppose that the oil of vitriol is employed :—

	£.	s.	d.
1 ton of bones, at 5*l*.	5	0	0
One-third of a ton of oil of vitriol, at 10*l*. .	3	13	4
	£8	13	4

These quantities of acid and bones will make more than $1\frac{1}{3}$ ton of superphosphate, because the oil of vitriol does not contain sufficient water to furnish the gypsum with its quantity for combination and 10 per cent. of moisture to the product. The acid will be diluted of course in the process, and the amount of product will be as nearly as possible $28\frac{1}{2}$ cwts., at a cost for materials alone of 8*l.* 13*s.* 4*d.*, which is at the rate of about 6*s.* 2*d.* per cwt., or 6*l.* 3*s.* 4*d.* per ton. A saving of rather more than 1*l.* on every ton of superphosphate would be effected by using the brown acid instead of the oil of vitriol: but even at this rate, and supposing the manure of composition, such as we have described it at page 226, to be sold at 7*l.* per ton, a margin of less than 2*l.* per ton would be left to the manufacturer for superintendence, profit, interest of capital, labour, bags, wear and tear of machinery and utensils, and delivery to his customers. Whether this is sufficient to meet the exigencies of the case it is not for me to say; but without offence to the class of manure-dealers, who have as fair right as any other traders to get an adequate return for their capital and energies, I may perhaps be allowed to say that the better the article they can produce for a given price, the more widely extended will the use of this valuable manure become, and the greater will be the advantage derived, not only by themselves, but also by the agricultural interest to which they minister. I believe that the average value and efficiency of the manure as supplied throughout the country is far below what it should be and might readily become with the application of sufficient intelligence and information on the part of those who manufacture it. The truth is, that the production of superphosphate of lime is not so easy a matter as it would seem at first sight; there are many circumstances which tend more or less to modify the result, and the neglect of any one of the necessary precautions will lead to failure.

With the conviction that there are many makers on the small scale who would gladly receive such hints as a knowledge of the chemistry of the subject will place at their disposal, I shall proceed shortly to recapitulate the circumstances which should be taken into account in undertaking the manufacture of the manure.

Practical suggestions for the making of Superphosphate of Lime.—The first point to be considered is the material or materials to be employed. Bones form at present the great staple of this manufacture; but if the consumption should largely increase, recourse must be had, to a very great extent, to the mineral phosphates. Bones may be used without previous preparation; but it is far more economical on the whole that they should have been previously boiled to remove the grease, which

is of much more value for soap and candle making than it can be as manure. Bones so treated will of course come cheaper to the manure-maker after a valuable material has already been extracted from them: the same may be said of the gelatine or glue. As a whole there will be a greater gain to the community by the separation of the fat, and more or less of the glue, than by the employment of these substances as manure. It will be for the maker of superphosphate to decide whether he can better buy the bones in this state or carry on the preliminary operations himself. If he limits himself to the former he will do well to ascertain that the bones are not over wet or mixed with such a quantity of impurity as to diminish materially their value.

If a mineral phosphate is to form the basis of the manure, he should be careful that, with a fair proportion of phosphate, it does not contain too large a percentage of carbonate. As we have already shown, every pound of carbonate of lime leads to a certain waste—an equal waste—of acid; the same is true of fluoride of calcium, which equally requires to be overcome before the phosphate can be acted upon. Care must also be taken that the phosphoric substances, particularly of the chalk and greensand formation, are really what they profess to be. With a similar shape and an appearance which would deceive any but those who are accustomed to them, some of the fossils of the greensand are found to be almost entirely composed of carbonate of lime or of flint; and even where the genuine substances are collected they are frequently mixed up with so much sand and worthless matter as to render them wholly unfit for the manufacturer's purpose. The same caution is required in the purchase of bone-ash and animal charcoal; I have known several instances where a substance has been bought, and even used, for a considerable period as animal charcoal, which upon examination was found to contain no portion of phosphate of lime.

Of the acid I have already spoken: if oil of vitriol is employed, its density and consequent strength should be ascertained; it is, however, much more economical to employ the weaker or brown acid. Next to the purity of the materials themselves is their mechanical condition. Whether bones or mineral phosphate are employed, they should be reduced to the finest state practicable; the finer the better. Contact of the acid and phosphate in every part is essential to perfect action, but the very nature of the products makes it difficult of accomplishment. The sulphate of lime formed, being insoluble, clogs up the entrance to the bones and covers over the particles of the mineral phosphates so as to prevent the remainder of the acid from being brought into play. It is by no means unusual to find a specimen of superphosphate in which abundance of acid has been employed, but in which

much of it has remained in its original state for want of proper contact, and the result is an inferior manure produced at a cost which should have ensured success.

For the same reason dilution of the acid to such an extent as it may be fairly carried out consistently with the subsequent drying up of the product is, in all cases, advisable. A rise of temperature, whenever it can be effected, is of great use; the mere mixture of bones and sulphuric acid will produce much heat, but if the acid has to be diluted the use of boiling water will prove of great assistance; considerable caution must, however, be employed in the mixing of the water and acid on account of the violence of the action.

The mode of mixing the materials has also a most material influence on the result. It might reasonably be supposed that a given quantity of acid would ultimately produce the same amount of action, whether it were mixed by degrees or at one time; such however is not the case. At page 217 it was stated that the phosphate of lime of 100 lbs. of bones would be entirely converted into bi-phosphate by 44 lbs. of oil of vitriol; now, supposing that we divided the heap into two portions, adding the whole acid, after proper dilution, to one, and subsequently, when the action had time to take place, mixing in the other heap; instead of the acid removing just so much lime as would convert the whole phosphate into bi-phosphate, it would go much further than this, and would thoroughly decompose the bi-phosphate at first formed, all the sulphuric acid becoming neutralized and phosphoric acid being liberated; but this acid is comparatively a weak acid, and acts very slowly and inefficiently on the remainder of the phosphate. I have found that, though a solution of phosphoric acid readily dissolves sufficient precipitated phosphate of lime to convert it into bi-phosphate, it acts with comparative feebleness on crushed bones, and requires days or weeks to dissolve the mineral phosphates. Nothing, therefore, can be more unsatisfactory than the mixing of bones or other phosphoric substances in large heaps with the acid; whatever care is subsequently taken to mix them, the action must inevitably be partial and incomplete. The manufacture of superphosphate of lime as a trade should always be carried on with the aid of machinery; the acid and bones or mineral phosphate should be brought together in their proper proportions little by little, so that the bi-phosphate should be produced at once by abstraction of the lime, and not by a slow and uncertain action of liberated phosphoric acid on further quantities of phosphate of lime.

The necessary utensils for this purpose need not be complicated; it is only requisite that the powdered phosphoric substance and the diluted acid should be brought together in proper pro-

portions with means of sufficient agitation. If the proportions are properly regulated and the quantity of water not too great, the mixture will need no further attention, but will dry up of itself: and this brings me to the subject of the mode of drying up the acid compound. Some makers, after producing a compound of phosphate and acid of a semifluid or pasty character, add absorbent substances to dry it into a fit state for sale. In some cases they use a further quantity of the same phosphoric substance for the purpose, but it is evident that it would serve the same purpose to add the full amount in the first instance, provided sufficient means existed to produce a perfect mixture as where machinery is brought into play. But when two or more substances are employed, such for instance as coprolites and crushed bones or animal charcoal, it is by no means indifferent how the mixture is made; in that case the rule should be to add the acid to that substance which is in itself and in its natural state least valuable to vegetation, and to use the more valuable substances in the drying up of the mixture.

Suppose a manufacturer intends to make superphosphate from coprolite and crushed bones, and that for want of proper apparatus he is necessitated to resort to the addition of one or other of these substances to dry up the acid material, let him by all means add the acid to the coprolite, which is comparatively valueless without such treatment, and employ as his drying material the crushed bones, which in their unchanged state are still most valuable manures; this rule can, with requisite judgment, be applied in all cases. Coprolites, whether of the crag or green sand, and Spanish or American phosphates, are comparatively useless as manures until they have been acted on by acid. Crushed bones, animal charcoal, phosphatic-guanos, are all more or less efficacious without such treatment. If it be necessary to use one phosphoric substance as the principal, and the other as the accessory in the manufacture—if one is to be employed as the basis and the other as a mere mechanical absorbent—let the mineral phosphate be the one selected for action by the acid, and the bones, guano, or animal charcoal as the substances for mechanically drying up the product.

Mode of applying Superphosphate of Lime.—A few words on the practical use of this manure will complete the present paper. If the view now taken of the action of superphosphate be correct—that is to say, that its efficacy consists in the production in the soil of a *precipitated* and therefore highly comminuted phosphate, and moreover of the distribution of this phosphate through a large mass of soil—it follows, that to ensure its successful employment the farmer must see that nothing that he does to it should be opposed to either one or other of these conditions.

If superphosphate of lime be properly made, the farmer receives from the dealer a soluble compound of phosphoric acid and lime, which by the influence of moisture will be distributed through the soil, and, meeting with bases capable of combining with it, be reconverted into a compound insoluble indeed in water, but of easy solubility in nature's solvent, water impregnated with carbonic acid. I have already said that the *production* of the precipitated phosphate is one thing—its *distribution* is another: the latter is fully as important as the former. Those who use superphosphate of lime must therefore take care that nothing that they mix with in the act of applying the manure to the soil shall have the effect of destroying its solubility before it has a chance of becoming properly distributed.

The usual mode of applying this manure is to drill it with some dry substance under the seed—burnt earth, cinders, coal or wood ashes, charcoal, &c., are the substances employed for this purpose. To burnt earth there would appear to be no objection, provided that it does not contain too much carbonate of lime. Coal or wood ashes appear to me undesirable for the purpose on account of the alkaline carbonates which they contain, especially the wood-ashes. By neutralizing the phosphoric acid of the bi-phosphate, they reduce by one half at least the power of *distribution* upon which we have ventured to lay much stress: the nature of this action has been before explained in speaking of the addition of kelp. To charcoal, as a substance with which to drill superphosphate of lime, these arguments do not apply, and its use appears quite free from objection.

The question of the best method of applying manures is one which involves theoretical and practical considerations of the greatest moment. In the old or broadcast system of manuring it is evident that the *whole soil,* to a given depth, was made to participate in the benefits of the application, and the whole soil therefore was in the position of what Tull called a "pasture" or feeding ground for plants. The natural tendency of the roots of plants is undoubtedly to spread themselves and to run out in every direction in search of food.

The practice of drilling manures in close proximity to the seed is founded upon the supposition that, by supplying the plants with food immediately within reach, you thereby diminish the amount of energy which they are otherwise called upon to expend in seeking for it, and enable them in a given time to obtain the means of building up a greater amount of vegetable structure. But the acceptation of this theory involves two assumptions—the first, that plants with a supply of food within their reach do really content themselves with that supply and cease to throw out their roots to a greater distance; the second, that the manures are such

as require no preparation by combination with the materials of the soil, but are at once, and in the form in which they are applied, taken up by the plant and appropriated to its nourishment. The former of these assumptions is in a manner dependent on the latter, for, if plants can really take up and make use of the different substances furnished to them in manure in the state in which we apply them, there seems no good reason why they should wish for more. But I confess that the unexpected aspect which has been given to the question of the food of plants by the experiments made by Mr. Thompson and myself would lead to a far different conclusion. The impression left on my mind by these experiments, unsatisfactory and incomplete as they still are, is that the office of the soil, not merely as a place for the roots of plants to take root in and obtain a mechanical attachment to, but as an agent for the alteration and preparation of these manures—itself taking part in the necessary changes—is of the very last importance to healthy vegetation. Of this circumstance there is no doubt—that healthy vegetation of land plants will not proceed in water whatever may be the care and attention given to supplying the plants with food, whilst the same food distributed through a given quantity of soil becomes at once available to the sustenance of plants. It is also certain, from the experiments alluded to, that the ingredients of manure, both mineral and organic, do enter into a new state of combination with the soil, and that consequently, in the ordinary course of nature, plants do directly take these means of support and growth from the compounds so formed. It needs therefore only a very small amount of logical reasoning to convince us that, as this is the usual and natural, so it must be the healthiest and best form in which the substances which constitute the food of plants can be offered to their acceptance. Sulphate and muriate of ammonia, added to water in which the roots of plants are placed, not only fail to nourish but actually destroy them. On the other hand, these salts distributed through a small portion of soil produce the most luxuriant vegetation. If again we find that sulphate of ammonia, and the muriate of the same base, immediately after mixture with the soil cease to remain as such, but enter into union with certain ingredients of the soil, are we not justified in believing that it is this new combination, or something derived from it, which is effectively the food of the plant, and that the soil is an all-powerful agent in the preparation of that food?

I am unwilling to form a conclusion of this importance without due and careful consideration, but it does appear, to say the least, questionable whether plants can *healthily* subsist on the crude and various substances supplied in manure until these substances

have undergone the modifications which mixture with the soil will produce.

The bearing of this subject on the drilling of manures is evident; this mode of application almost presupposes the power of the plant to feed upon the unaltered ingredients of manure; and although undoubtedly these substances do come into contact with a certain quantity of the soil, it seems to me well worth consideration whether, by carrying out the plan of drilling manures in its fullest sense, we may not be overlooking the fact that we thereby limit the roots of the plant to an area of "pasturage" infinitely smaller than they might advantageously enjoy, and whether a more moderate use of this method and a partial return to the system which should make the whole soil participate in the benefits of manure is not more consonant both with practical information and scientific truth.

With regard to superphosphate of lime it may be said, that of all manures it is that which is most wanted *near* the plant, as its office is mainly to influence the early growth when the area of the roots is small and the distance to which they extend very circumscribed; this is true, but it does appear that there is something in the turnip that particularly delights in phosphoric acid and its compounds, and I cannot doubt that the same influence which it feels so notably in its early stages will not be entirely lost in its more mature condition, and that a ready supply of this mineral will promote its healthy vegetation at every stage; under this impression I offer the two following suggestions for experiments with superphosphate of lime.

1st. To add the quantity of superphosphate of lime intended for the turnip-crop—or a considerable portion of that quantity—to the farm-yard manure also devoted to that purpose.

This might be done either by placing it in layers with the manure some time previously, or by dissolving it in a small quantity of water, or the liquid running from the dung, and repeatedly pumping it back again. In this case, of course, no waste of liquid must be allowed.

2nd. To incorporate the phosphate of lime dissolved in water with a considerable quantity of soil, so as to form a kind of compost, which should be turned over once or twice, and exposed to the action of water only to such an extent as to favour the distribution of the soluble phosphate. This compost would subsequently be drilled for turnips.

I repeat that these are suggestions only for *experiment* on a

limited scale, and not for adoption into practice, unless they should be proved by experience to be of practical advantage.

Dr. Ure's Table of the Quantity of Oil of Vitriol, of Sp. Gr. 1·8485, and of Anhydrous Acid, in 100 parts of dilute Sulphuric Acid, at different Densities.

Liquid.	Sp. Gr.	Dry.	Liquid.	Sp. Gr.	Dry.	Liquid.	Sp. Gr.	Dry.
100	1·8485	81·54	66	1·5503	53·82	32	1·2334	26·09
99	1·8475	80·72	65	1·5390	53·00	31	1·2260	25·28
98	1·8460	79·90	64	1·5280	52·18	30	1·2184	24·46
97	1·8439	79·09	63	1·5170	51·37	29	1·2108	23·65
96	1·8410	78·28	62	1·5066	50·55	28	1·2032	22·83
95	1·8376	77·46	61	1·4960	49·74	27	1·1956	22·01
94	1·8336	76·65	60	1·4860	48·92	26	1·1876	21·20
93	1·8290	75·83	59	1·4760	48·11	25	1·1792	20·38
92	1·8233	75·02	58	1·4660	47·29	24	1·1706	19·57
91	1·8179	74·20	57	1·4560	46·48	23	1·1626	18·75
90	1·8115	73·39	56	1·4460	45·66	22	1·1549	17·94
89	1·8043	72·57	55	1·4360	44·85	21	1·1480	17·12
88	1·7962	71·75	54	1·4265	44·03	20	1·1410	16·31
87	1·7870	70·94	53	1·4170	43·22	19	1·1330	15·49
86	1·7774	70·12	52	1·4073	42·40	18	1·1246	14·68
85	1·7673	69·31	51	1·3977	41·58	17	1·1165	13·86
84	1·7570	68·49	50	1·3884	40·77	16	1·1090	13·05
83	1·7465	67·68	49	1·3788	39·95	15	1·1019	12·23
82	1·7360	66·86	48	1·3697	39·14	14	1·0953	11·41
81	1·7245	66·05	47	1·3612	38·32	13	1·0887	10·60
80	1·7120	65·23	46	1·3530	37·51	12	1·0809	9·78
79	1·6993	64·42	45	1·3440	36·69	11	1·0743	8·97
78	1·6870	63·60	44	1·3345	35·88	10	1·0682	8·15
77	1·6750	62·78	43	1·3255	35·06	9	1·0614	7·34
76	1·6630	61·97	42	1·3165	34·25	8	1·0544	6·52
75	1·6520	61·15	41	1·3080	33·43	7	1·0477	5·71
74	1·6415	60·34	40	1·2999	32·61	6	1·0405	4·89
73	1·6321	59·52	39	1·2913	31·80	5	1·0336	4·08
72	1·6204	58·71	38	1.2826	30·98	4	1·0268	3·26
71	1·6090	57·89	37	1·2740	30·17	3	1·0206	2·446
70	1·5975	57·08	36	1·2654	29·35	2	1·0140	1·63
69	1·5868	56·26	35	1·2572	28·54	1	1·0074	0·8154
68	1·5760	55·45	34	1·2490	27·72			
67	1·5648	54·63	33	1·2409	26·91			

XIV.—*On Claussen's Flax-Cotton.* By Edward M'Dermott.

There are few questions agitated in the present day which, whether viewed with reference to their magnitude, or the importance of the interests involved, deserve a more careful and attentive consideration on the part of all interested in the prosperity and welfare of the country, than those which have reference to the production

and supply of the raw material required for the manufacture of textile fabrics in this country. There are dependent upon the various branches of the cotton, flax, wool, and silk manufactures, upwards of one-tenth of the whole population, while the capital embarked in them is not less than 100,000,000*l.* The whole of the raw material consumed in these manufactures is in one form or other to be obtained only from agricultural labours. One of the most striking features in connection with this great subject is the extremely small portion of the enormous supply required which is contributed by the agriculturists of our own country. For the supply of cotton our manufacturers are of necessity dependent upon foreign countries; a nominally small proportion of the flax required in the linen manufactures is produced at home, and for a large proportion of the wool, and for the whole of the raw silk, we are also indebted to the foreign producer.

This state of dependence for the supply of these staple articles is greatly to be deprecated, not less on account of the manufacturer, who is thus constantly exposed to the evil of uncertain supply, arising either from the vicissitudes of the seasons, or the nature of the commercial policy which may be adopted by the producing country. The pressure arising from this state of things was never more seriously felt than at the present moment. Our manufacturers are at present almost entirely dependent upon the United States for their cotton, and so long as the requisite supply could be obtained their production went on increasing at a rate which appears almost incredible. In 1800 they consumed only 56,000,000 lbs. of cotton, but within the short space of the last half-century the consumption increased to the enormous amount of 770,000,000 lbs., or upwards of 1000 tons per day, being an increase of about 1300 per cent. Proceeding at this enormous rate of increase, the manufacturers were suddenly arrested by a deficient supply, prices rose upwards of 50 per cent., mills were stopped, and a large number of the working population were in consequence thrown out of employment. A conviction is now fast gaining ground among those who possess the fullest opportunity of investigating the subject,* that the supply of cotton from the United States has now reached its limit, and that it is not only impossible to produce a larger quantity in the cotton-producing districts, but that the rapid extension of home manufactures in the States, opening up a large demand for the raw material there, will prevent us for the future obtaining that enlarged supply which is necessary for our rapidly extending manufactures, and for affording the means of employment to our constantly increasing working population.

* *Vide* 'Remarks on the Statistics of the Cotton Trade,' by G. R. Porter, Esq., Secretary to the Board of Trade.

In our linen manufactures a somewhat analogous state of things is found to exist. Like the cotton manufactures they too are dependent for their supply of flax—notwithstanding that the article can be profitably produced at home—upon foreign countries. The linen trade, like that of its rival, cotton, has during the last twenty years made most rapid strides, having more than doubled its production within that period. Recently, however, and more especially during the past and present years, its progress has been retarded by insufficient supplies of the raw material from Russia, Belgium, and the other continental flax-producing states.

In the face of these deficiencies of supply, and the constantly increasing demands for employment on the part of our working population, it becomes a matter of most serious consideration how far the recurrence of such evils may be prevented by the extended cultivation of flax at home. We are aware that among agriculturists there exists very generally a strong prejudice against the cultivation of the crop, founded mainly upon the opinion of its exhaustive character, and the great difficulty which has hitherto existed in bringing the flax into a suitable condition for the market, and of obtaining for it even when so prepared an adequate return for the risk and trouble of its preparation. These objections have not been altogether unfounded, and their origin is to be sought in the general want of knowledge of the true character of the flax-plant and in the prevalence of wasteful and injurious systems of cultivation and preparation of the fibre. The progress of science, however, the attention which has been bestowed upon the subject by enlightened agriculturists both of England and Ireland, the exertions of the Royal Flax Society in disseminating useful information on the subject, and, above all, the recent discoveries of the Chevalier Claussen, and the publicity which has been given to them through the medium of the Royal Agricultural Society of England and 'The Morning Chronicle,' which first brought the subject under public notice, have done much towards placing the question of flax culture upon an entirely different footing. These altered circumstances require but to be made fully known, in order to obtain a more extended cultivation of flax in this country.

It is scarcely necessary to enter into any arguments, or adduce any facts, to prove that both the soil and climate of the United Kingdom are well adapted for the cultivation of flax. It may be sufficient to state that it has been grown to some extent in almost every part of the country, that it has been cultivated with success upon a newly reclaimed Irish bog; in the fen districts of England; on the summit of the Wicklow mountains; by Mr. Warnes upon the Beacon Hill of Norfolk; in the Highlands of

Scotland; in the midland counties of England; by Sir Richard A. O'Donnell on the western shores of Galway and Mayo; upon rich and poor, clayey and gravelly, alluvial, and indeed upon almost every variety of soil.

That it is not, when properly managed, an exhaustive crop, was clearly demonstrated at the meetings of the Agricultural Society in February, during the discussion which took place upon the general question of flax cultivation and the invention of the Chevalier Claussen. Among other noblemen and gentlemen conversant with the subject, who then expressed their opinion, was Lord Monteagle, who stated that some of the land which he had sown with flax had been previously rather exhausted, but that by cultivating the crop well, that land had become better than any other on his estate; no meadow, indeed, yielded such capital grass as that on which the flax had been grown. Mr. Druce, of Ensham, in Oxfordshire, stated that he grew excellent turnips in the same year on his flax land without manure, and that his son had found that some wheat sown after flax was one of the best crops he had ever grown. In Somersetshire, he stated, it was a standing proverb that "good wheat crops always followed flax." The opinions of Sir R. A. O'Donnell, Mr. Warnes, and several other experienced flax-growers, were quoted to the same effect.*

Possessed however of the merely negative quality of not exhausting the land more than any ordinary crop, we should hardly feel justified in calling the attention of agriculturists to a consideration of the importance of flax cultivation. Our agriculturists require not merely a crop which has the recommendation of not being greatly exhaustive, but also one which is remunerative in its character. Upon this point, too, ample proof exists to show that flax possesses this desirable property. Turning to the last Report of the Royal Irish Flax Society, we find that particulars are there given of the flax-crops of 51 farmers of the county of Down, the average profit obtained being at the rate of 7*l.* 1*s.* 4½*d.* per acre. In the cases of these growers, however, not one of them had saved the seed—a portion of the crop equally as valuable as the fibre—for one of the great advantages of flax is that it is a double crop, producing both seed and fibre. We have given an instance of the profit resulting from the fibre alone. In cases where the seed only is saved, and the straw or fibre is used as litter, the crop is equally profitable. An instance of this occurs in the case of Mr. Beare, of Norfolk, whose crop yielded 26 bushels of flax-seed; and in that of Mr. Fuller, who stated at the meeting of the Royal Agri-

* Mr. Fox, of Beaminster, has just pulled several acres of very fine flax, grown after turnips, without manure. These instances show that flax may occupy any place in the ordinary rotation.

cultural Society that the produce of his seed was 9*l.* 12*s.* per acre. The published experience of Mr. Warnes is to the effect that, in his own case, where both seed and fibre were saved, his profit upon 14 acres of flax was upwards of 6*l.* per acre over that of his wheat, the latter being an excellent crop. In the preparation of the fibre, however, for market, an amount of risk and trouble is necessary to be incurred on the part of the grower, to which few persons would be willing to expose themselves. The example of Mr. Druce, who saved his seed, and disposed of his flax in the straw, without any further preparation for market, appears best adapted to the wants and requirements of the growers of flax in this country. Mr. Druce sowed last year 5 acres 2 roods 36 perches of flax; his total expenses of cultivation were 36*l.* 10*s.* 4*d.* The produce of the crop he gives as follows:—

	£.	*s.*	*d.*
Sale of flax-seed 20¼ bushels per acre—116¼ bushels, at 8*s.*	46	10	0
Sale of flax-straw—12 tons, 2 cwt. 2 qrs. at 3*l.* per ton .	36	7	6
Sale of chaff, at 5*s.* per acre	1	8	7
Total receipts	£84	6	1

Leaving a net profit of 47*l.* 15*s.* 9*d.* on the 5 acres 2 roods 36 perches, being equal to 8*l.* 6*s.* 2*d.* per acre.

The question arises, how is it that, with such facts before our agriculturists, the cultivation of flax is not more general in this country? The answer is to be found in the difficulty and uncertainty of finding a market for the produce. For one who, like Mr. Warnes, has the perseverance necessary to overcome the obstacles connected with the steeping and dressing of the flax, there are hundreds who have neither the facility nor the inclination; while the case of Mr. Druce, who was able to dispose of the crop in the straw at a remunerative price, is an exception to the general rule. No wonder, therefore, that, in the face of the existing difficulties, the cultivation of the plant has been so small, and that, notwithstanding the increased demands for it, and the sustained efforts of the Royal Irish Flax Society, there has been both in this country, and in Ireland, up to the present year, a gradual diminution in the breadth of land sown with flax. The position in which the grower is placed, and the difficulties with which he has to contend, even in Ireland, where the great seats of the flax manufacture are situated, were thus forcibly stated by Lord Monteagle, one of the Vice-Presidents of the Royal Irish Flax Society, at the meeting of the Royal Agricultural Society of England. He said,—

"He had been induced more to restore the growth of flax in that part of Ireland in which he resided, than to introduce it, as the cultivation had ceased on account of the want of markets for the produce. His tenants too were induced to join in the cause, as well as the Earl of Devon, and other influential landowners of the district. They all succeeded, grew good flax and the specimens received the favourable notice of the Flax Society,

his Lordship's sample being valued at 63*l.* only at that time, on account of the lowness of prices, but which would now fetch 100*l.* His tenants did not, however, succeed so well as himself; they could not transport the flax in its bulk; they had no water power; and he was unwilling to erect steam power till assured of a market. The consequence was, that he had to take all the flax off the hands of his tenants, so that at that time he had more stacks of flax than of wheat on his farm, with no means of turning them to account."

We do not propose to enter into the merits of any of the existing systems for preparing the flax by steeping, whether in running streams, in pits, in hot or in cold water, or by the process known as dew-retting. Full particulars and details upon these subjects, and statements of the relative merits of each plan, are to be found in the reports of the Royal Irish Flax Society; each no doubt possesses its peculiar advantages, but to the growers they one and all appear to present difficulties sufficient to form an insuperable bar to an extended flax culture in this country. What is wanted for the flax-grower is a ready and profitable market for his produce, without being subjected to any greater amount of difficulty than he experiences in the preparation of his wheat or other cereal produce. If this desideratum can be obtained, it will not be long before flax takes its due position in the ordinary rotation of crops in all parts of the country. We are anxious that no mistake should exist upon this subject, and that it should be clearly understood that the present small quantity of flax produced at home is owing solely and entirely to the difficulty and uncertainty of obtaining a market for the produce.

In connexion with the existing demand for flax and hemp, it should be borne in mind that the mills and factories in existence are already supplied, and that the British grower can only expect to find there a market for his produce, in proportion as he may be enabled to displace the foreign producer. It is to the opening up of new markets, and of new sources of demand, that we are anxious to direct attention, as well as to the supply of existing markets. The present position of the cotton manufacturer, the uncertainty of a continuous sufficient supply of the raw material, and the discoveries of the Chevalier Claussen, by which flax may be employed to a considerable extent as a substitute for cotton, and may be adapted for mixing with wool;—to which we referred in our opening remarks, appear to point in the direction whence these new sources of demand will arise. Considering the importance to the farmers of this country of every fact affecting the cultivation of flax, the Chevalier Claussen was requested by Mr. Pusey, M.P., the chairman, to attend a meeting of the Council of the Royal Agricultural Society, for the purpose of explaining his invention, and of stating his views with respect to the increased demand which might possibly arise for the article

of flax by the manufacturer, in consequence of his discoveries. The subject occupied the attention of the Council at three of its meetings, and the liveliest interest was evinced by the members present. In order that the subject may be fully understood by our readers, we propose to point out in detail the nature of the invention of the Chevalier Claussen.

The history which that distinguished gentleman, who was formerly an extensive cotton-grower and slave-owner in the Brazils, gives of the causes which first led him to experiment upon flax, for the purpose of "cottonizing" it, is exceedingly interesting, inasmuch as it shows that his success was the result of inductive research, and not the offspring of mere chance. He states that, in wandering along the luxuriant banks of one of the Brazilian rivers, his attention was attracted to a white down-like substance, adhering to the branches of trees overhanging and touching the stream. On obtaining a quantity of it, he was so pleased with its character that, thinking he had discovered some hitherto unknown vegetable product, he was determined to trace it, if possible, to its source, and to ascertain the plant which had yielded it. With the ardour of a naturalist he commenced his task, and eventually found that the substance had been washed from a bed of flax-straw, the produce of some of his own land, and which, long before, he had caused to be thrown, as useless, near the banks of the river. To this heap the swollen waters had occasional access—fermentation and the decomposition of a portion of the plant had taken place—and in time the influence of natural chemistry had so separated the filaments of the flax fibre as to give the mass a cotton-like appearance; and some of it, having been washed into the river, had been arrested by the overhanging branches. Although the substance thus accidentally discovered was far from being in that condition which would fit it for the hands of the cotton-spinner, yet, even in its then imperfect state, it led the Chevalier to entertain the idea of the possibility of completing, by the aid of artificial chemistry, that which nature had but partially accomplished.

In order that the nature of the invention may be perfectly understood, it is necessary to state that the stem of the flax-plant consists of several perfectly distinct parts: there is the woody matter, or straw, which supports the plant while growing; the fibre, which lies upon the outer surface of this inner cylindrical straw; and one or more substances, such as gum, and resinous and glutinous matters, which cause the fibres to adhere to each other and to the surface of the straw. The fibre is the only part required for the manufacturer, and must, previous to its being used, be separated from the other constituents of the plant, and upon the completeness of such separation depends to a great extent the value of the produce for manufacturing purposes. If one of the flax-stems be

rubbed in the hand, it will be found that a partial separation of the straw has been obtained, and its bulk has in consequence been proportionately reduced. Taking advantage of this property of the flax, the Chevalier Claussen has constructed a machine * for the purpose of enabling the grower thus to separate the straw from the fibre. The possibility of effecting this without steeping has been known for some years, and the merit of its discovery is not claimed by the Chevalier Claussen. But considering that hitherto the great difficulty with all growers of flax has been its preparation for market, and that, even in cases similar to that of Mr. Druce, where the crop was disposed of in the straw as it came from the field, the great bulk of the crop rendered its transport to any distance almost impossible, it was thought that, if means were placed at the disposal of the grower by which a reduction of the bulk of the crop might be obtained without injury to the fibre, and at an expenditure of labour not greater than the ordinary farm occupation of threshing, he would be enabled to avail himself of the best market which might offer for his produce. In addition to this, the straw obtained in the process of separation would be available for returning to the soil, and thus prevent that exhaustion which must of necessity take place in the case of flax, as in all other crops, where the whole of the produce was removed from the soil.

When thus separated the fibre is adapted to the manufacture of sail-cloth, ropes, cordage, canvas, and other coarse fabrics, for which a very large demand exists, and, in consequence of its great strength and freedom from waste, it may be advantageously employed as a substitute for Russian hemp in the production of a large proportion of these articles. It is also adapted in this stage for the process of steeping required to bring it into a fit state for the ordinary flax spinner or linen manufacturer, and it is equally suited for undergoing the further manipulations required in order to adapt it under Chevalier Claussen's process for spinning upon the ordinary cotton or woollen machinery. The great difficulty, therefore, in connexion with the preparation of the crop for market on the part of the grower is at once removed by this, the first stage in the process which we are considering. So far as the agriculturist is concerned our remarks might stop here, did we not consider it necessary to carry our observations a stage further, for the purpose of showing the practicability of the new process, and its adaptation to the requirements of that new and extensive demand which must of necessity arise for flax when employed as

* Upon the adaptation to its purpose and cheapness of this machine depends the benefit which the agriculturist will derive from the ingenious invention of the Chevalier Claussen; the bulk of flax straw to be transported from the farmyard to the manufacturer is at present so great in proportion to the price received per ton for the straw, as to militate extensively against the cultivation of flax for the purpose of manufacture in England.—W. Miles.

a substitute or auxiliary in the cotton and woollen manufactures of the country.

The machine above referred to, as we have said, removes the straw only, and but partially disintegrates or separates the fibres, which are held together by an adhesive substance. Hence the coarseness of the fibres and their suitability for coarse and strong fabrics only. In order to adapt it for the linen manufacture, as also to carry it one stage further in the process of preparation for the cotton or wool spinner, it is necessary to obtain a more complete separation of the fibres. This object is to be accomplished by the removal of the resinous and glutinous substance which binds them together; and as it does not appear that mechanical power will completely effect this, recourse is had to chemical means. These substances are therefore dissolved by the chemical action of fermentation, which takes place under the ordinary modes of steeping, whether in hot or cold water; and the application of mechanical power in the process of scutching afterwards separates the fibres, and leaves them in a fit state for the various manipulations required previous to flax-spinning.

The existing processes of steeping resorted to for the purpose of obtaining this separation are found not only to occupy a very large portion of time, but they are also not sufficiently uniform in their action to produce that complete separation required in the flax for spinning on the ordinary cotton machinery, and even in the preparation of the fibre for the ordinary branches of linen manufacture, they possess many disadvantages which it would be desirable to see removed alike for the interests of the grower, who may have the convenience and facility for thus preparing his flax, as for the manufacturer himself. In order to obtain this more complete separation of the fibre, desirable alike for the flax as for the cotton spinner, the Chevalier Claussen adopts the plan of boiling the flax (either in the straw, as it comes from the field, or in the state in which it leaves the grower's hands, with its bulk partially reduced by the removal of the straw) for two or three hours in a weak solution of caustic soda. The action of the soda dissolves completely these resinous and other substances, while, by its combination with the oleaginous matters of the plant, it produces a soapy kind of liquid, which removes at the same time all the colouring matter—leaving it, unlike flax steeped upon the ordinary mode, perfectly free from all stain and impurity, and thereby facilitating greatly the after processes of bleaching or dyeing, whether in the yarn or in the finished cloth.

The advantages resulting from this mode of treating the flax may be stated to be,—that the preparation of long fibre for scutching is effected in less than one day, and it is always

uniform in strength, and entirely free from colour; that the flax can be bleached in the straw at very little additional expenditure of time or money; that the former tedious and uncertain modes of steeping are superseded by one perfectly certain with ordinary care; and that in consequence of a more complete severance of the fibres from each other, and also from the bark and boon, the process of scutching is effected with labour considerably less than that usually employed.

These advantages apply only to the preparation of the flax for the linen manufacturer, and to the production of a long fibre suited to the requirements of the flax machinery. The great difference in the length of the staple of cotton as compared with flax renders necessary a very different arrangement of the parts of the mechanism employed in spinning the two materials. The first step required to be taken in order to spin flax upon cotton machinery is therefore to effect such a reduction in the length of the fibre as may suit it to the machinery upon which it is to be spun. This operation, apparently very simple, is, nevertheless, an exceedingly difficult one, the greatest accuracy being required in cutting, as, if any of the portions of fibre exceed the required length, they will "bite" in the rollers, and the yarns produced from them will be unequal in strength, and present the appearance of being "overworked." A very nicely-adjusted machine, similar in its operation to the ordinary "chaff-cutter," has now, however, been constructed, and the difficulty has, we believe, been successfully overcome. The required lengths may be obtained either by cutting the flax in the straw as it comes from the field;—with its bulk reduced by the partial removal of the straw;—or even after it has undergone the boiling process just referred to.

Had nothing more, however, been required, in order successfully to spin flax upon cotton or woollen machinery, than merely to reduce the length of the fibre, the spindles of Lancashire and Yorkshire would long since have been employed in spinning flax where now cotton or wool alone is spun. There is a vast difference, however, between the harsh and elastic fibres, and the specific gravity of flax, as compared with the soft down-like substance of the cotton-pod, which must be removed before the one can be substituted for the other upon the same description of machinery. Even after having passed through the boiling process, the flax fibres are coarse and harsh as compared with cotton, while the quantity in length of yarn obtained from equal weights of the two materials will, in consequence of the difference of specific gravity between the two substances, be so greatly in favour of cotton as completely to preclude the possibility of its profitable substitution by flax. Thus, for instance, 1 lb. of fair-bowed

Georgia cotton, spun into 30's, will yield 25,200 yards; while 1 lb. of flax, spun into "line" of a number about equal to that of the cotton-yarn, would produce but 21,000 yards, giving an advantage of 4000 yards in the pound to cotton over flax. In addition to this, the yarn would be produced from the raw cotton by cotton machinery at an expense of less than 3*d.*, while that of the flax would be more than double that sum when prepared by the flax machinery. This is a difficulty which has hitherto lain at the root of every attempt to spin flax successfully and profitably upon cotton machinery, and the solution of which constitutes the great difference between the process of Chevalier Claussen and all other attempts previously made to spin flax upon cotton or woollen machinery.

A minute attention to the structure of the flax fibre, combined with his knowledge of the properties of cotton, suggested to the inventor a mode by which this difficulty might be overcome. The long fibres of the flax-plant are arranged around each other in small bundles, presenting, under the microscope, somewhat the appearance of a bundle of rods, or the Roman fasces. It became obvious that, if by any process these minute hair-like substances could be further subdivided, the required increase in length and proportionate diminution in bulk or coarseness would be obtained. But how was this separation to be obtained? Ordinary mechanical means were useless for such a purpose. Hair-splitting, even upon a small scale, has always been considered as partaking somewhat of the impracticable; and to accomplish this process upon a large scale—to split or divide this fine hair-like substance by hundredweights at a time, and to do it at a trifling cost—would appear to be beyond the bounds of possibility. The feat has, however, been accomplished by the Chevalier Claussen—and what is more, it is effected instantaneously. What ordinary mechanical powers failed to accomplish has been not only successfully, but instantaneously performed, by the mechanical action of chemical forces applied to the interstices of the fibres.

The means by which this is accomplished are simple and beautiful, and they form an exceedingly interesting illustration of chemical powers long known and universally recognised. We have already stated that in one of the processes—that employed by the Chevalier Claussen in the preparation of the flax for the linen manufacture—the fibre was boiled in a solution of caustic soda. In preparing the article for the cotton-spinner the flax also undergoes a similar boiling and cleansing process, after which it is taken out of the vat containing the solution of caustic soda, washed, and placed in another containing a solution of carbonate of soda, in which it remains till fully saturated with

the salt; it is then placed in a third vat containing a weak solution of sulphuric or other acid. The hollow cylinders of the fibres, by the laws of capillary attraction, speedily become charged with the acidulated solution in which they are placed; and the acid, coming in contact with the soda which the fibres had taken up in the first and second solutions, generates carbonic gas, the expansive force of which splits or divides the fibres into a vast number of ribbon-like filaments, which, examined under the microscope, present the appearance of raw cotton.

After having passed through these several stages, and having been dried, carded, and spun in the ordinary method, it will be found that the quantity of yarn produced from a given quantity of flax, instead of being less than a similar weight of cotton, will be equal to it, or considerably more, the produce varying in quantity according to the character of the fibre operated upon and the strength of the material employed. The specific gravity of the cottonized substance will also be precisely similar to that of cotton itself. At the meeting of the Council of the Royal Agricultural Society of England in February last, Professor Way exhibited this very interesting process. We give the account of the experiment in the words of Mr. Hudson, the Secretary of the Society:—

> "Although we have long been practically familiar with the expansive effects of aëriform fluids suddenly disengaged chemically from an apparently solid and inert substance like gunpowder, either in fire-arms or the blasting of rocks, and with their elastic recoil when released from the pressure of condensation, as in the air-gun or the liquid gases of Dr. Faraday, we were not prepared for so beautiful an instance of the application of this principle as the one Chevalier Claussen has given us in the splitting of vegetable fibre, by conveying into its interstices the carbonic acid gas concealed in condensation and chemical alliance with soda, and then setting it free by the addition of acid, which breaks off that alliance by its own superior elective affinity for the alkali. Means shown in their result to be so powerful, and in their operation so gentle yet decisive, gave to the simple experiment, made in the presence of the Council by Professor Way, more the air of a new instance of natural magic, than the sober reality of an ordinary operation of natural laws, of which the application only was novel; and its effect on the meeting was accordingly both singular and striking, occasioning evident marks of their agreeable surprise and admiration at the result obtained. The flax fibre soaked in the solution of carbonate of soda was no sooner immersed in the vessel containing the acidulated water than its character became at once changed from that of a damp rigid aggregation of flax to a light expansive mass of cottony texture, increasing in size like leavening dough or an expanding sponge. This change was no less striking when this converted mass in its turn was placed in the next vessel, which contained the hypo-chlorite of magnesia, and became at once bleached, attaining then the colour, as it had just before received the texture, of cotton."

Two points yet remain to be noticed on this subject, viz. whether the substance produced under this treatment can be

used with advantage by our manufacturers, and, if so, the cost at which it can be produced. According to the answers given to these questions must depend the opinion whether the Chevalier Claussen's invention be a really valuable one, or a merely interesting and ingenious application of the laws of chemistry. We have endeavoured to obtain information upon this subject, and the result has been to lead us to believe that the invention must be classed under the former head. With respect to the possibility of manufacturing the fibre upon the ordinary cotton or woollen machinery, there appears to be but one opinion among all whom we have had an opportunity of consulting on the subject, and several of the largest manufacturers have expressed themselves as perfectly willing to take any quantity that may be supplied to them. We have seen samples of the yarns spun on the ordinary machinery formed entirely of flax, and others of a mixture of flax and cotton, flax and wool, and flax and silk, which we have no hesitation in describing as of excellent quality. We have also seen samples of similar yarns dyed in various colours, and which appear to take the dye equal to any yarns formed entirely of cotton, silk, or wool. The cloth woven from the yarns possesses a degree of softness, and strength, and clearness of appearance, which is seldom found to exist in any other fabrics formed entirely of the one material. The mixture of the flax with the wool appears to answer exceedingly well; and inasmuch as the two substances may be worked together in any proportion, it follows that our woollen manufacturers will be able to produce cloths as durable as those formed entirely of wool, at a price considerably less than they have hitherto been able to manufacture them.

With respect to the price at which the "flax-cotton," or "British cotton," as it is termed, can be produced, we are indebted to the Chevalier Claussen for the following statement, the accuracy of which he assures us cannot be impeached. He states that—

	£.	s.	d.
"On the average, 5 tons of flax-straw will produce 1 ton of British cotton, the cost of which, at 3*l.* per ton, would be	15	0	0
The expenses of "breaking," "cutting," and "blowing," will not exceed	1	19	0
Chemical preparations and ingredients employed	1	5	0
Total cost of 1 ton of flax fibre, or "British cotton," equal to fair quality American cotton	18	4	0
Add to this (where required) the bleaching	1	0	0
Washing, drying, &c. &c.	1	16	0
Total cost of the "British cotton" bleached and washed, per ton	£21	0	0

—or $2\frac{1}{4}$*d.* per lb., and which will readily sell at from 4*d.* to 6*d.* per lb."

For wool, he states that the expenses of preparation are about the same; but it requires a further "blowing" and carding, which processes are extra, say 1*d.* per lb., but it will then sell to the woollen manufacturers at from 6*d.* to 10*d.* per lb.

If these statements can be borne out when the process is carried out upon an extensive scale, our agriculturists will be enabled to supply the cotton and woollen manufacturers with a fabric adapted to their machinery, and without requiring the slightest outlay on their part, for the purpose of adapting it to the new material, at a price considerably less than that at which cotton can be profitably grown and imported from the United States, or any other cotton-producing country. Referring to the official list of prices at Liverpool of "American uplands" and of Surat and Madras cotton during the last 20 years, it appears that the lowest price at which cotton was sold was in 1845, when the imports were unusually large, and that then the prices were, for "uplands," from $3\frac{3}{8}d.$ to $4\frac{5}{8}d.$ per lb., and for Surat and Madras from $2\frac{1}{2}d.$ to $3\frac{3}{8}d.$ per lb. The highest price was in 1835, when "uplands" ranged from 9*d.* to $11\frac{1}{4}d.$, and "Surats" from $6\frac{5}{8}d.$ to $8\frac{3}{4}d.$ per lb. The average price for the whole period was for Surats about 5*d.*, and for uplands about $6\frac{1}{2}d.$ per lb.; while Chevalier Claussen states that the cost at which his British cotton can be produced does not exceed $2\frac{1}{4}d.$ per lb.

An additional advantage presented to the manufacturer is, that the flax-cotton, when delivered, is in a much cleaner state than foreign cotton is imported, and that consequently he will have to incur less expense in the preparatory stages of putting it on his machinery. It will of course be fully understood, from the mode of preparation which we have described, that the process of producing "flax-cotton" commences at the same stage as that of the preparation of the "fibre" for the ordinary linen manufacture, and that it is not proposed to convert "flax," as ordinarily known in the flax market, and which has been steeped and prepared to suit one branch of manufacture, into a substance suited to another of a totally distinct character.

Enough has, we think, been stated to induce our agriculturists to bestow a calm and careful consideration upon this really important and national question, to watch the progress of the flax movement, and to endeavour to secure for themselves those advantages which, should the invention be successfully carried out, may not improbably be as exclusively enjoyed by the foreign producer as is the supply of the present demand for flax in this country. We have purposely abstained from mixing up with the consideration of this question the advantages which would result to the grower from being enabled, by the culture of the flax-crop at home, to obtain, at a less cost, a better description

of oil-cake and cattle-food than he at present obtains from foreign countries, and thus to increase the quantity of his stock and manure, and improve the condition of the other crops in his rotation. These subjects, as well as that of the additional employment which the cultivation of flax would afford to the labouring population, may be treated of more appropriately in a consideration of the general question of flax culture. There is one point, however, in connexion with the preparation of flax-cotton, bearing upon the interests of the agriculturist, which ought not to be overlooked, viz. that the flax will not be required to be pulled, as in cases where it is desirable to obtain a fine flax for the present linen manufacture, before it is fully and completely ripe. The grower will thus be enabled to obtain, in addition to the fibre or straw, a valuable crop of fully ripened seed, available for the purposes of the oil-crusher or for feeding his cattle.

We are informed that already several foreign countries are on the *qui vive* on the subject, and that the State of Massachusetts has sanctioned the formation of a company for the purpose of carrying out the invention upon a large scale in that State.

EDWARD M'DERMOTT.

XV.—*On American Phosphate of Lime.* By the SECRETARY.

THE Secretary having been directed by the Council to make special inquiries on the subject of the occurrence of mineral phosphate of lime in the United States, and in reference to the specimen of that substance which Dr. Daubeny had forwarded to the Duke of Richmond, replies were received from his Excellency the American Minister, Dr. Daubeny, Sir R. I. Murchison, Sir Charles Lyell, Captain W. H. Smyth, Dr. Shawe, Professor Johnston, of Durham, Mr. Johnson, Secretary of the New York State Agricultural Society, and Dr. Cooke, Professor of Mineralogy in Harvard University, and laid before the Council on the 25th of June last. The following results may be deduced from this correspondence:—

1. The mineral phosphate of lime has been found in abundance in the American States of New Jersey and New York; and there is a great probability that supplies of it will be discovered in other States of that Union, as well as in Canada; it is also not improbable, from analogical considerations, that this crystalline substance may be found to exist among the metamorphic masses of the Highlands of Scotland and elsewhere.

2. The specimen from New Jersey, forwarded by Dr. Daubeny to the Duke of Richmond, had the appearance of a remarkable variety of crystalline rock; but the formation in which it oc-

curred was not stated. It was found by Professor Maskelyne, of Oxford, to contain 95 per cent. of the phosphates of lime, iron, and alumina. Its importation was made by Messrs. Jevons, of Stamford-place, Liverpool. One vein alone, discovered in New Jersey, would supply the English market for many years.

3. In the State of New York a great mass of this mineral had been discovered, and a shaft had already been sunk to the depth of nearly 30 feet. This vein occurred at Crown Point, near Lake Champlain, in Essex County, and the abundance of the mineral was so great as to lead to the conclusion that this mine contained an inexhaustible supply; the locality was also favourable for facility of transport and ready shipment. This vein consisted of grains and crystals; and on analysis, in America, had been found to contain a much larger proportion than the Jersey mineral, of which some specimens yielded only about 40 per cent. of the phosphate of lime, while the Crown Point mineral, as reported by Mr. Johnson, gave 80 per cent. of that substance, free from chalk, containing only a small amount of quartz in grains, and of the fluoride and chloride of lime. It is very soft, and pulverizes easily, and is more readily dissolved than the Jersey variety. It can be delivered in London in the rough state, or powdered ready for use, as may be thought most desirable. By single-horse power two tons a-day may easily be ground.

4. The price at which the Jersey phosphate was first offered for sale at Liverpool was 5*l.* 5*s.* per ton; but its interest immediately ceased, in a commercial point of view, when the importers, on fallacious grounds of supply and demand, injudiciously raised the price to 7*l.*, forgetting that there were already other forms of phosphate of lime in this country available to the English farmer. It is now fully believed by moderate and intelligent Americans that the United States phosphate can be afforded in the English market at such a price as will render it a cheap fertilizer; and, as it can easily be reduced to powder, its value cannot be doubted, provided it be treated with sulphuric acid, and thus rendered suitable as a manure to those crops for which phosphate of lime has been found by experience to be advantageous.

5. Professor Johnston, of Durham, to whose personal visit to the United States we probably owe the attention thus paid to this mineral, occurring so abundantly in that part of the world, remarks:—" American farmers in general have not the knowledge to appreciate the value of such a manuring substance as this, nor the ability to purchase it when manufactured into superphosphate of lime; the discovery, therefore, will be a boon, for the present, to both countries. It will make more abundant and cheap the means of fertility which our soils require; while, by

supplying a new article of traffic only saleable in Great Britain, it will form a new bond of connexion between our kindred nations."

6. Dr. Cooke and Dr. Daubeny having called the attention of the Council to the information relating to this mineral contained in Dana's "System of Mineralogy," the following abstracts have accordingly been made from different parts of that work:—

(1) *Localities and Association of Occurrence.*

At Blue-hill Bay, Maine—(remarkably good specimens) with arsenical iron, molybdenite, galena, fluor-spar, black tourmaline, black oxide of manganese, rhodonite, bog manganese, wolfram.

At Rumford, Maine—in the same district with yellow garnet, idocrase, pyroxene, scapolite, graphite.

At Jackson, New Hampshire—with drusy quartz, tin ore, arsenical pyrites, native arsenic, fluor-spar, magnetic iron ore, molybdenite, wolfram, copper pyrites, arsenate of iron.

At Piermont, New Hampshire—with micaceous iron, heavy spar; green, white, and brown mica.

At South Westmoreland, New Hampshire—(remarkably good specimens) with molybdenite, blue feldspar, bog manganese, quartz, fluor spar, copper pyrites, oxide of molybdenum and of uranium.

At Bolton, Massachusetts—with scapolite, petalite, sphene, pyroxene, nuttalite, diopside, boltonite, magnesite, rhomb spar, allanite, yttrocerite, cerium ochre, spinel.

At Boxborough, Mass.—with scapolite, spinel, garnet, augite, actinolite.

At Chester, Mass.—with hornblende, scapolite, zoisite, spodumene, indicolite, magnetic iron.

At Chesterfield, Mass.—with blue, red, and green tourmaline; cleavelandite, lithia, mica, smoky quartz, microlite, spodumene, kyanite, rose beryl, garnet, quartz crystals, staurotide, tin ore, columbite, variegated copper ore, zoisite, uranite.

At Hinsdale, Mass.—with brown iron ore, zoisite.

At Lancaster, Mass.—with kyanite, chiastolite, staurotide, pinite, andalusite.

At Littleton, Mass.—with spinel, scapolite.

At Middlefield, Mass.—with glassy actinolite, rhomb spar, steatite, serpentine, feldspar, drusy quartz, zoisite, nacrite, chalcedony, talc.

At Norwich, Mass.—(very fine specimens) with black tourmaline, beryl, blende, quartz crystals.

At Sturbridge, Mass.—with graphite, pyrope, bog ore.

At Williamsburgh, Mass.—with zoisite, pseudomorphous quartz, sero and smoky quartz, galena, pyrolusite, copper pyrites.

At Haddam, Connecticut—with chrysoberyl, beryl, epidote, tourmaline, feldspar, anthophyllite, garnet, iolite, chlorophyllite, antomolite, magnetic iron, adularia, columbite, mica, white and yellow iron pyrites, molybdenite, allanite, sulphuret of bismuth.

At Litchfield, Connecticut—with kyanite and corundum, andalusite, ilmenite, copper pyrites.

At Middletown, Connecticut—with mica, lepidolite, green and red tourmaline, albite, feldspar, columbite, prehnite, garnet, beryl, topaz, uranite.

At Crown Point, New York—with garnet, massive feldspar, epidote, Epsom salt, magnetic iron.

At Long Pond, New York—with garnet, pyroxene, idocrase, coccolite, scapolite, magnetic iron ore, blue calc spar.

At Moriah, New York—with zircon, calc spar, actinolite, labradorite, mica, specular iron.

At Diana, New York—with scapolite, tubular spar, green coccolite, feldspar, sphene, mica, quartz crystals, drusy quartz, cryst. pyrites, magnetic pyrites, blue calc spar, serpentine, rensselaerite, zircon, specular iron ore, iron sand.

At Corlaer's Hook, New York—unassociated with other remarkable minerals.

At Two Ponds, in Munroe, New York—with pyroxene, chondrodite, hornblende, scapolite, zircon, sphene.

At Amity, New York—(good specimens) with spinel, garnet, scapolite, hornblende, idocrase, epidote, clintonite, magnetic iron, tourmaline, warwickite, chondrodite, ilmenite, talc, pyroxene, rutile, zircon, corundum, feldspar, sphene, calc spar, serpentine.

At Edenville, New York—(good specimens) with chondrodite, hair-brown hornblende, tremolite, spinel, tourmaline, warwickite, pyroxene, sphene, mica, feldspar, mispickel, orpiment, rutile, ilmenite, scorodite, copper pyrites.

At Putnam Valley, New York—with zircon and sphene.

At Edwards, New York—with brown and silvery mica, scapolite, quartz crystals, actinolite, tremolite, specular iron, serpentine.

At Gouverneur, New York—with calc spar, serpentine, hornblende, scapolite, feldspar, loxoclase, tourmaline, pyroxene, rensselaerite, serpentine, sphene, fluor, heavy spar, rutile, black and copper-coloured mica, tremolite, asbestus, specular iron, graphite, idocrase, mica, quartz, spinel, pyrites.

At Hammond, New York—(remarkably good specimens, quite unique) with zircon, feldspar, pargasite, heavy spar, pyrites, purple fluor.

At Rossie, New York—(good specimens) with calc spar, heavy spar, quartz crystals, chondrodite, feldspar, pargasite, pyroxene, mica, fluor, serpentine, automolite, pearl spar, graphite, serpentine, zircon.

At Greenfield, New York—with chrysoberyl, garnet, tourmaline, mica, feldspar, graphite, arragonite (in iron mines).

At Anthony's Nose, New York—(good specimens) with pyrites, calcite.

At West Farms, New York—with tremolite, garnet, stilbite, heulandite, chabazite, epidote, sphene.

At Yonkers, New York—with tremolite, calc spar, analcime, pyrites, tourmaline.

At Suckasunny, on the Morris Canal, New Jersey—good specimens of brown apatite with magnetic pyrites.

At East Bradford, Pennsylv.—with green, blue, and grey kyanite.

At Leiperville, Pennsylv.—(good specimens) with beryl, tourmaline, garnet, cryst. feldspar, mica, kyanite, damourite, sillimanite, red garnet, mica; (ordinary specimens) with andalusite, tourmaline, mica, grey kyanite.

At Springfield, Pennsyl.—with staurotide.

At Chesnut Hill, Pennsyl.—with mica, serpentine, dolomite, asbestus, nephrite, talc, tourmaline, sphene, tremolite.

At Germantown, Pennsyl.—with mica, feldspar, beryl, garnet.

At Dixon's Feldspar Quarries, Delaware—(good specimens) with adularia, albite, beryl, mica, leelite, cinnamon stone, magnesite, serpentine, asbestus, black tourmaline, indicolite, sphene, kyanite.

At Magnet Cove, Arkansas—with brookite, schorlomite, elœolite, magnetic iron, quartz, green coccolite, garnet.

At Bay St. Paul, Canada East—with ilmenite.

At Burgess, Canada West—(good specimens) with pyroxene, albite, mica, sapphire, sphene, copper pyrites, black spinel, spodumene.

At Goetineau River, Canada West—with calcite, tourmaline, hornblende, pyroxene.

At Grand Calumet Island, Canada West—with phlogopite, pyroxene, sphene, idocrase, serpentine, tremolite, scapolite, brown and black tourmaline, pyrites.

The *apatite*, or mineral phosphate of lime, usually occurs in crystalline rocks. It is often found in veins in gneiss or mica-slate, and particularly those containing tin and iron ore; also in granular limestone. It is sometimes met with in serpentine, and occasionally, as in Spain, in ancient volcanic rocks. Among foreign localities are Ehrenfriedersdorf, in Saxony; Schlackenwald, in Bohemia; Caldbeck Fell, in Cumberland; Devonshire; St. Gothard, in Switzerland. The greenish-blue variety called *moroxite* occurs at Arendal, in Norway, and Pargas, Finland. The *asparagus-stone*, or *spargelstein* variety, which is obtained at Zillerthal, in the Tyrol, and Villa Rica, Spain, is translucent, and has a wine-yellow colour; it is embedded in talc. The *phosphorite*, or massive radiated varieties, are mostly obtained from Estremadura, in Spain, and Schlackenwald, in Bohemia. The *eupyrchroite* variety of Emmons is similar. Magnificent crystals of *apatite*, or mineral phosphate of lime, are found in St. Lawrence county, State of New York, in white limestone, along with scapolite, sphene, &c. One crystal from Robinson's Farm, in Hammond, was nearly a foot in length, and weighed 18 lbs. Smaller crystals are abundant, and the prisms are frequently well terminated. Besides the locality in Hammond, fine crystals are obtained about a mile south-east of Gouverneur in a similar gangue, and also in Rossie, with sphene and pyroxene, two miles north of the village of Oxbow. Also on the bank of Vrooman lake, Jefferson county, in white limestone, fine green prisms from half an inch to five inches long; Sanford Mine, East Moriah, Essex county, in magnetic iron ore, which is often thickly studded with six-sided prisms; also at Long Pond, Essex county; near Edenville, Orange county, in prisms from half an inch to twelve inches long, of a bright asparagus-green colour, imbedded in white limestone; and in the same region, blue, greyish-green, and greyish-white crystals; two miles south of Amity, emerald and bluish-green crystals; at Long Pond, Essex county, with garnet and idocrase; at Greenfield, Saratoga county, St. Anthony's Nose, and Corlaer's Hook, less interesting; fibrous mammillated (*eupyrchroite*) at Crown Point, Essex county, about a mile south of Hammondsville. In New Hampshire, crystals, often large, are abundant in the south part of Westmoreland, four miles south of the north village meeting-house, occupying a vein of feldspar and quartz in mica-slate, along with molybdenite; some fine crystals at Piermont, New Hamp-

shire, in white limestone, on the land of Mr. Thomas Cross. In Maine, on Long Island, Blue-hill Bay, in veins ten inches wide, intersecting granite. In Massachusetts, crystals occasionally six inches long are obtained at Norwich (north-west part), in grey quartz; at Bolton, abundant, the forms seldom interesting; also sparingly at Chesterfield, Chester, Sturbridge, Hinsdale, and Williamsburgh. In Pennsylvania, at Leiperville, Delaware county; in Bucks county, three miles west of Attleboro. Apatite, or mineral phosphate of lime, has also been found near Baltimore, Maryland; at Dixon's Quarry, Wilmington, Delaware, of a rich blue colour; on the Morris Canal near Suckasunny, New Jersey, of a brown colour, in massive magnetic pyrites; also at Perth, Canada.

(2) *External Characters.*

Hexagonally crystalline; also globular or kidney-shaped, with a fibrous or imperfectly columnar structure, and massive, with a granular structure. Lustre vitreous, inclining to subresinous. Streak, white. Colour usually sea-green, bluish-green, or violet-blue; sometimes white; also occasionally yellow, grey, red, and brown; none bright. Transparent—opaque. A bluish opalescence sometimes in the direction of the vertical axis, especially in white varieties. Cross fracture conchoidal and uneven. Brittle. It is about $3\frac{1}{4}$ times heavier than water.

(3) *Chemical Composition.*

According to Professor Rose, apatite is composed of—

Phosphate of lime (or bone-earth) . . .	92·3
Fluoride of calcium (or Derbyshire spar) . .	7·7
	100·

The following analyses represent the composition of 100 parts of specimens from Norway, Spain, and the Tyrol, respectively:—

	From Snarum in Norway.	From Cabo di Gata, in Spain.	From Arendal in Norway.	From Greiner in the Tyrol.	From St. Gothard, in the Tyrol.
Phosphate of Lime . . .	91·13	92·066	92·189	92·16	92·31
Chloride of Calcium . .	4·28	0·885	0·801	0·15	a trace.
Fluoride of Calcium . .	4·59	7·049	7·010	7·69	7·69
	100·00	100·000	100·000	100·00	100·00

Rammelsberg makes the composition of 100 parts of an apatite from Schwarzenstein in Zillerthal:—Lime, 49·66; phosphoric acid, 42·58; with calcium, 4·06; chlorine, 0·07; fluorine, 3·63. In a phosphorite from Estremadura, Dr. Daubeny found 14 per cent. of fluoride of calcium. Mineral phosphate of lime is infusible when heated alone by means of the blow-pipe; but melts without difficulty into a glass of crystalline structure on cooling, when mixed with bi-phosphate of soda or with common borax: it also fuses when mixed with carbonate of iron. In nitric acid

it dissolves slowly, without effervescence. Some varieties are phosphorescent.

(4) *Varieties.*

Mineral phosphate of lime was termed *apatite* by Werner, from a Greek word signifying "deceptive," in allusion to the mistakes made by the older mineralogists with regard to the nature of its many varieties. It is also known by the terms: spargelstein, asparagus-stone, phosphorite, moroxite, chrysolite, eupyrchroite, augustite, and pseudo-apatite. The variety known as *talc-apatite,* from chlorite slate in Schischimskian Mountains, near Slatoust, contains in 100 parts—lime, 37·50; magnesia, 7·74; phosphoric acid, 39·02; sulphuric acid, 2·10; chlorine, 0·91; oxide of iron, 1·00; fluorine, insoluble matter, and loss, 11·73. *Francolite* is an apatite from near Tavistock, in Devonshire. It occurs in small masses of irregular aggregated crystals, having a somewhat mammillated surface. According to the analysis of T. H. Henry, 100 parts are composed of—lime, 53·38; iron and manganese, 2·96; phosphoric acid, 41·34; fluorine and loss, 2·32.

Professor Jameson gives in the article Mineralogy, in Brewster's Encyclopædia (pages 484-5), an interesting statement of the varieties of apatite, their localities of occurrence, and respective chemical composition. We have only space on this occasion to glance at a few points selected from that article.

1. *Foliated apatite* (common variety) occurs in tinstone veins, and also embedded in talc. It is found in Europe, in yellow foliated talc; and along with fluor-spar, in the mine called Stena-Gwyn, in St. Stephen's, in Cornwall; and at St. Michael's Mount, Godolphin-bal, in Breage, in the same county; also in various districts on the continent. In America it occurs in grains or hexahedral prisms in granite, near Baltimore, in Maryland; in granite and gneiss, along with beryl, garnet, and schorl, at Germantown, in Pennsylvania; in iron pyrites at St. Anthony's Nose, in the Hudson, in New York; in granite at Milford Mills, near Newhaven, in Connecticut; and at Topsham, in Maine, in granite. Klaproth found it to consist of lime 55, and phosphoric acid 45, with a trace of manganese.

2. *Conchoidal apatite* (asparagus variety) occurs imbedded in gneiss, near Kincardine, in Ross-shire; also in beds of magnetic ironstone, along with sphene, calcareous spar, hornblende, quartz, and augite, at Arendal, in Norway. In America it is found embedded in granite at Baltimore; in gneiss at Germantown, and in mica-slate in West Greenland. Klaproth ascertained the composition of two specimens of this variety: one from Zillerthal being almost pure phosphate of lime; while another, from Uto, contained only 92 per cent. of that substance, with 6 per cent. of chalk, 1 of silica, and a trace of manganese.

3. *Common Phosphorite.*—Occurs in crusts, and crystallised, along with apatite and quartz, at Schlackenwald in Bohemia, but most abundantly near Leigrosan in the province of Estremadura in Spain, where it is sometimes associated with apatite, and forms whole beds, that alternate with limestone and quartz. Pelletier found 100 parts to consist of—lime, 59·0; phosphoric acid, 34·0; silica, 2·0; fluoric acid, 2·5; muriatic acid, 0·5; carbonic acid, 1·0; oxide of iron, 1·0.

4. *Earthy Phosphorite.*—Occurs in a vein, in the district of Marmarosch in Hungary. Klaproth gives its composition as—lime, 47·00; phosphoric acid, 32·25; fluoric acid, 2·50; silica, 0·50; oxide of iron, 0·75; water, 1·00; quartz and loam, 11·50.

XVI.—*On Jatropha Manure.* By THORNTON J. HERAPATH.

To the Secretary of the Royal Agricultural Society.

SIR,

MY object in addressing these few lines to you is to call your attention, and that of the members generally, to a new description of manure, which has been recently brought before my notice. I allude to the "Jatropha manure," as it is called. This is the expressed cake of the "lamp-oil seed," the fruit of a variety of the castor-oil plant (*Ricinus communis*, var. *Major*), which is imported in pretty considerable quantities from the Cape de Verde Islands, &c.; and which, when subjected to pressure, furnishes an oil admirably adapted for the purposes of illumination, and for lubricating machinery.

The oil being excessively purgative and poisonous, however, it has been found impossible to employ the residuary cake, which of course still contains a portion of oil, for the feeding of cattle, for which purpose it would be otherwise well adapted. The only use, therefore, the manufacturers can put it to, is to sell it to the agriculturists as a manure.

Some of this Jatropha manure was recently sent to my father, Professor W. Herapath, for analysis. It was examined in our laboratory, and found to contain in 100 parts:—

Water	10·24
Organic matters	81·88
Ashes	7·88
	100·
Nitrogen per cent. in fresh cake . . .	4·20
,, ,, dried cake . . .	4·68

The composition of the ashes was as follows:—

			Per Cent. of Ash.
Soluble salts	0·48	=	6·193
Carbonates	1·66	=	21·070
Insoluble phosphates . .	4·22	=	53·554
Silica, grit, &c.	1·52	=	19·183
	7·88		100·

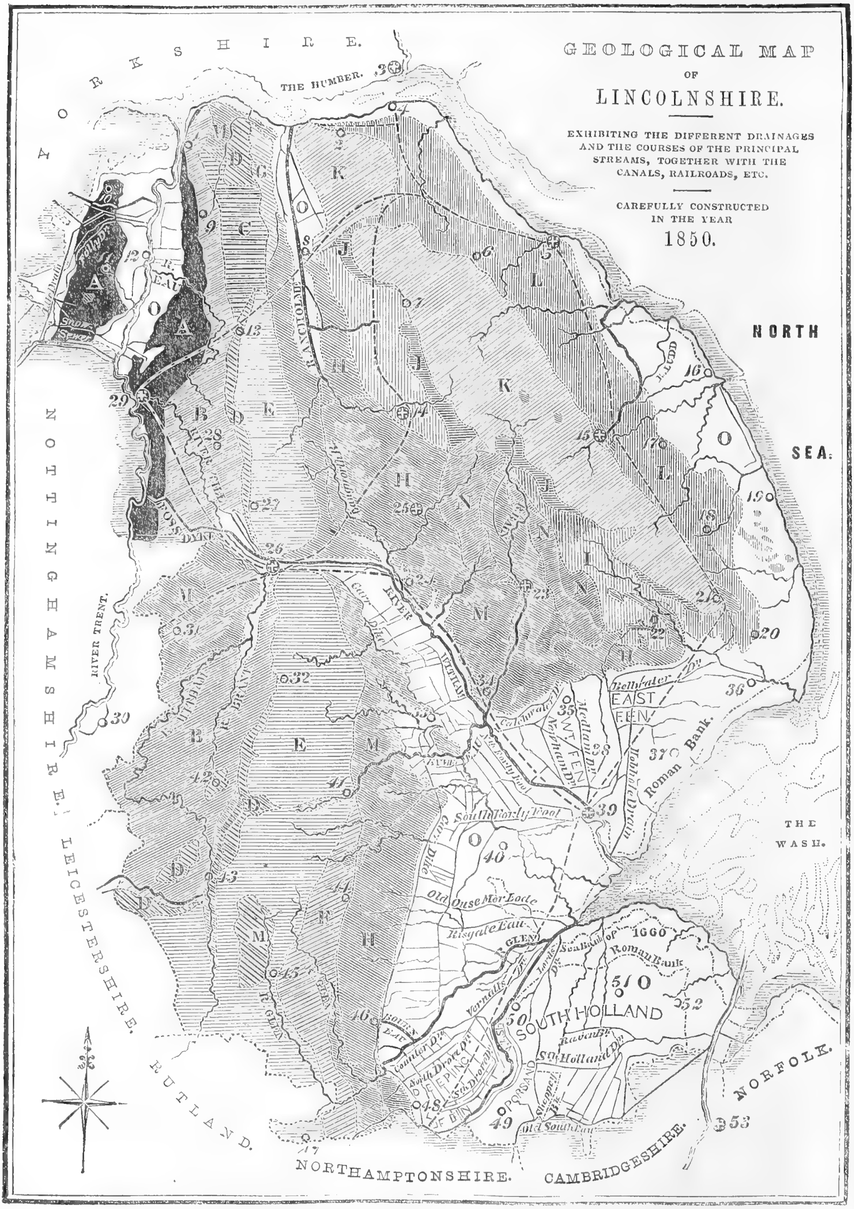
Below is given a table containing analyses by MM. Soubeiran and Girardin of the cakes of various oleaginous seeds.

Matters contained in 100 parts of oil-cake:—

	Pistachio.	Camelina.	Hemp.	Colza.	Beech.	Linseed.	Poppy.	Sesamum.
Water . .	12·0	14·5	13·8	13·2	14·0	11·0	11·0	11·0
Oil . . .	12·0	12·2	6·3	14·1	4·0	12·0	14·2	13·0
Organic matters	71·0	65·1	69·4	66·2	75·8	70·0	62·3	66·5
Ashes, or Mineral Salts	5·0	8·2	10·5	6·5	6·2	7·0	12·5	9·5
	100·	100·	100·	100·	100·	100·	100·	100·

In the organic matters of the seed there was of—

Nitrogen. .	6·07	5·57	6·20	5·55	4·50	6·00	7·00	5·57



Numbers and corresponding Towns on Map of Lincolnshire.

1. Burton-upon-Stather.
2. Barton.
3. Kingston-upon-Hull.
4. New Holland.
5. Great Grimsby.
6. Riby.
7. Caistor.
8. Brigg.
9. Froddingham.
10. Crowle.
11. Epworth.
12. Butterwick.
13. Kirton.
14. Market Raisen.
15. Louth.
16. Saltfleet.
17. Great Carleton.
18. Alford.
19. Sutton.
20. Burgh.
21. Gunby.
22. Spilsby.
23. Horncastle.
24. Bardney.
25. Wragby.
26. Lincoln.
27. North Carleton.
28. Walsingham.
29. Gainsborough.
30. Newark.
31. Swinderby.
32. Navenby.
33. Billinghay.
34. Tattershall.
35. Bolingbroke.
36. Wainfleet.
37. Wrangle.
38. Sibsey.
39. Boston.
40. Swineshead.
41. Sleaford.
42. Hough-on-the-Hill.
43. Grantham.
44. Folkingham.
45. Corby.
46. Bourn.
47. Stamford.
48. Market Deeping
49. Crowland.
50. Spalding.
51. Holbeach.
52. Long Sutton.
53. Wisbeach.

A New Red Sandstone. B Blue-Lias, Marlstone, &c. C Sand. D Inferior Oolite, &c. E Great Oolite. F Cornbrash. G Kelloway Sandstone, &c. H Oxford and Kimmeridge Clay.

I Lower Green Sand. J Red Clay, &c. K Chalk. L Plastic Clay. M Drift. N White Marl. O Alluvium, &c.

Canals, Rivers, &c., marked thus — Railways — Embankments

In the ashes there were—

	Pistachio.	Camelina.	Hemp.	Colza.	Beech.	Linseed.	Poppy.	Sesamum.
Soluble Salts	0·27	0·098	0·577	0·13	0·124	0·70	0·62	0·57
Phosphates reckoned as bone phosphate	1·20	4·200	7·100	6·50	2·100	4·90	6·30	3·20

Now, upon comparing the results of our analysis with those just given, it will be seen, that although the expressed cake of the Ricinus is certainly not so rich as many there named, still the proportion of fertilizing ingredients it contains is far from being contemptible. And, if it be true, as MM. Boussingault and Payen assert, that the value of a manure is in direct proportion to the quantity of phosphoric acid and nitrogen that it contains, then there can be no doubt that the Jatropha manure will ultimately prove a most useful and valuable fertilizer. No experimental trial, however, so far as I am aware, has been made with it, and consequently we do not as yet know how far experiment will bear out the deductions of science.

I remain, Sir, your obedient Servant,

THORNTON J. HERAPATH.

Mansion House, Old Park, Bristol,
July 25th, 1851.

XVII.—*Farming of Lincolnshire.* By JOHN ALGERNON CLARKE.

PRIZE REPORT.

THE county of Lincoln is celebrated both for its natural and acquired excellences: for the richness of its wide alluvial plains, the tillage of its bleak stony wastes, and the improvement of its fens by embankment and drainage. It is comprised between the parallels of 52° 40′ and 53° 43′ north latitude; and between the meridians 0° 22′ east and 0° 56′ west longitude. It is 74 miles in length, north and south, and 46 miles east and west; having an area of 2748 square miles, equivalent to 1,758,720 statute acres, or 1,652,165 acres exclusive of roads, rivers, &c. In size it is the second county in England; in *population* the thirteenth. By the census of 1841 it contained 362,717 inhabitants; being an increase since the return made in 1831 of 45,473. Of this number 57,561 persons are engaged in agricultural pursuits. The labourers amounted to 45,394; farmers and graziers to 11,288. Since the drainage of the Fens numerous villages have sprung up where previously was nothing but a watery waste, without house or inhabitant, and several of the bordering towns have doubled their population; so that the total population has increased nearly 4000 *per annum* during the last 40 years—a much more rapid increase than that of most agricultural counties.

The *climate* of Lincolnshire offers few peculiarities, except that along the whole line of coast the land is openly exposed to the

keen north-east winds, which are in some places severely felt in spring; and the south-eastern tract of marsh land is remarkably free from fog.* Theoretically, for about every 300 feet of elevation there is a loss of one degree of temperature; and notwithstanding the dryness and warmth of the calcareous and siliceous soils on the uplands (favourable to the early maturing of plants), the harvest on the loftier hills, which rise in some instances probably 600 feet, is fully a week or ten days later than in the flatter districts. When the high lands of north Lincolnshire were completely isolated by the vast swamps and wet marshes of the Trent, Ancholme, and Witham valleys, various endemical diseases were generated in the pestilential exhalations that arose; and twenty or thirty years ago, when the southern marshes and fens were subject to extensive flooding in rainy seasons—before steam commenced its labours with the scoop-wheel and pump—the ague seized great numbers of the inhabitants, with its shivering chills and fever fits. But the improvements in engineering and husbandry have greatly diminished the evaporation from the surface; the atmosphere has been rendered drier and warmer, and agues and intermittents much less frequent. The air is now as pleasant and salubrious as that of any other county; the average scale of mortality being about 1 in every 62, considerably less than the average of the whole kingdom. The mean annual depth of rain fallen in England in the 5 years 1839-43 was 27·54 inches: in the marshes near the Wash the average of those years was only 26·68 inches, and in Deeping Fen 28·79 inches. The average fall in Holbeach Marsh during the 9 years 1839-47 was 22·57 inches, in Deeping Fen 27·23 inches.

The *configuration* and *contour* of the county depend upon the two great watersheds which divide it into natural sections. Toward the western side the oolite hills run north and south from the Humber to Rutland and Leicestershire, having the broad Trent Valley on the west. From near the northern extremity of this range the Chalk Wolds stretch in loftier ridges to the south-east, making an acute angle with the former hills, and being about two-thirds their length. These two lines inclose between them an undulating tract of country, which sinks into the Fens, occupying the south-eastern portion of the county. The Marshes also skirt the Wolds on the north-east, lying between the high-lands and the German Ocean.

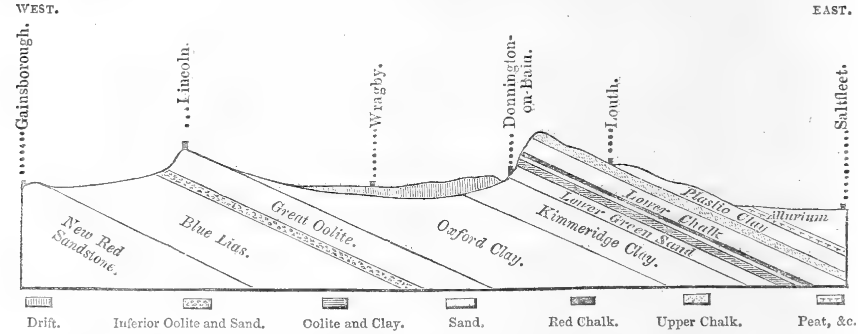
The first head for consideration is—

* Seven or eight years ago, in the autumn, a cold east wind, blowing for a long time in the same direction, produced a singular phenomenon in the neighbourhood of Spilsby, about thirteen miles from the sea, on the edge of the Wold Hills: the trees and hedges were whitened by crystallized incrustations of salt. This salt-blast had the effect of destroying many nettles.

1. *The Character of the Soils of the County, especially of its Marsh and Fen Lands.*

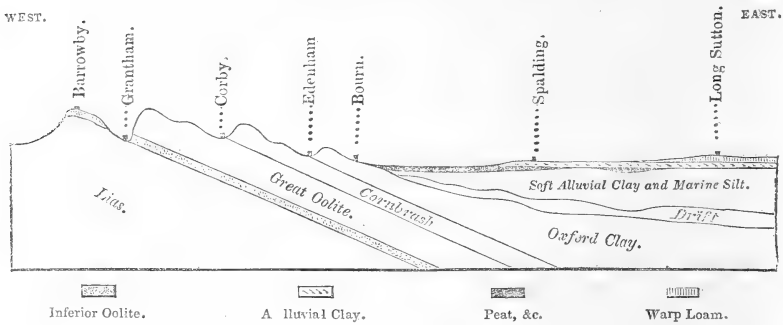
Lincolnshire possesses almost every variety of soil: from the thinnest white to the richest red sand; from the most incorrigible to the most fertile clay; from the coarsest gravel to the finest marl; from the most spongy to the most consolidated peat; from the sharpest silty warp to the fattest alluvial loam; and these soils are so intimately arranged and interspersed that the same district will afford light land for the production of green crops and summer pasturage for live stock. This peculiar diversity arises from the geological structure, there being no less than 8 of the great stratified formations in this county, besides a wide dispersion of different kinds of drift, and large tracts of peat and alluvium of almost every description. These formations are found (particularly in the northern half of the county) in parallel bands, ranging nearly north and south; and in describing the soils which rest upon them it will perhaps be best to consider each of the beds in its proper order. The lowest in the geological series is the *New Red Sandstone,* which appears on the north-western border of Lincolnshire, exhibiting the upper members of that group, *viz.*, variegated marls, sands, and gypsum. In the Isle of Axholme (or that portion of Lincolnshire west of the Trent) these beds form a ridge of high ground running north and south through the centre of the district from Owston and Haxey to Epworth, Belton, and Crowle, disappearing under the alluvial deposit on the east, and constituting the great base of the sandy and peaty deposits on the west. The soils on the high land are a clay loam and a rich sand loam, resting on clay, shale, and gypsum, but principally on the latter. In the hamlet of Low Burnham, near Haxey, there is a very considerable bed of gypsum, having an area of more than 500 acres and an average depth of from 12 to 14 feet. At Belton, &c., the gypseous rock is also found, and is prepared by machinery into sulphate of lime, for manure and for the flooring of farm-buildings and warehouses, being cheaper and more durable than any other kind of material. The white or pure gypsum is used by sculptors and plasterers. The black sand occupies also a part of the low lands, resting upon a white or reddish sand, as in the district south of Haxey. As the white sand is dry and porous it forms a natural subsoil drainage for this land, which is therefore generally good. When the white sand is at the surface the soil is light and unproductive. The soil adjoining the Trent is alluvial loam or "warp;" and in all the northern half of the isle there is next a belt of lower land, consisting of a dark grey sand upon white sand; some portions of it are very poor. Interspersed among the low sands is a considerable

Section across North Lincolnshire, or the Division of Lindsey, from the River Trent at Gainsborough to the German Ocean.

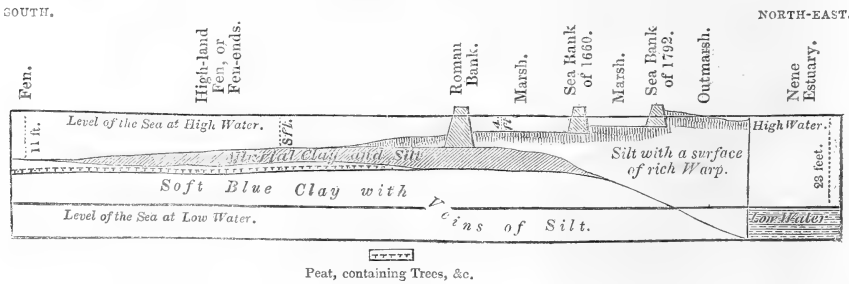


Further north, the Kelloway Sandstone and Gritstone seem to appear above the Great Oolite; and the Marlstone or upper beds of the Lias rise into a ridge of hill between the Oolite range and the Trent.

Section of South Lincolnshire, or the Parts of Kesteven and Holland, from Leicestershire to the Wash.



Section of 12 miles across the south-east portion of South Holland, from Cambridgeshire to the Nene Estuary.



[The section referred to in the description of the Ancholme drainage is withheld, being incorrect, and of little importance.]

extent of peat and peaty sand; and it is in this central division of the isle that the chief improvements by flooding from the river have been effected. West of this band, towards Wroot, &c., the surface is peat.

On the east side of the Trent, the red sandstone appears in the parish of Alkborough as a dark sand-loam skirting the steep declivity of the hills toward the south; and as the low land widens out (between Messingham and Butterwick, &c.) forms a breadth of low sand between the alluvium of the river and a peaty tract which divides it from the hills. Here (as in the Isle) the great improvements by the process called "Warping" have been accomplished upon the middle district of sand. About 2 miles east of St. Kinnal's Ferry, a hill of red pebbly sand rises from the flat of barren dry blowing sand, which lies in bare heaps or fern-clad patches; and further to the east is a wide moor on a higher level than the flat just mentioned, and consisting of a peaty sand on a red sand with white veins. Unlike the hill, which is destitute of herbage, this moorland is completely matted with mosses and heath, but the largest vegetation consists of tufts of black rushes and bunches of furze; and the lower portions are boggy with watercourses and stagnant plashes. This extends to Scotton, where the formation disappears from the surface, and stretches southward to Corringham. The red sand, in some places concealing valuable beds of alabaster, continues by Gainsborough and Knaith in the shape of low hills overhanging the Trent to Marton, &c., forming a fertile soil, in some places rich, but with a narrow tract of marsh next the river; and so reaches to Newark in Nottinghamshire, its eastern boundary averaging about 2½ miles distance from the Trent.

The *Lias* formation has a larger area than the red sandstone, but both occupy only a small proportion of the surface of the county. At Whitton-on-the-Humber the lias hill (lying upon the red sandstone) rises abruptly from the edging of marsh-land on the margin of the united Ouse and Trent waters, and, presenting a bold scarp sometimes exceeding 200 feet in height to the west, runs nearly parallel with the Trent at about 1 to 3 miles distance for 15 or 20 miles. It is of the marlstone series, composed of alternate layers of clay and stone, and pervaded by numerous springs of water (some of them petrifying), forming brooks, which, as the hill falls gradually for 2 or 3 miles to the eastward, flow in that direction, and then northward to the Humber at Wintringham Haven. The surface soil, for some distance from its brow, is a cold clayey loam, containing many fossil shells, and extends from Burton-on-Stather to the neighbourhood of Gainsborough with but little interruption. Much care is required in working this land, as it must be neither too wet nor too

dry. It contains probably a considerable portion of oxide of iron.

From between Scotton and Kirton, where the clay is probably not more than 2 miles in breadth, this bed widens out to the south so as to attain a width of 4 or 5 miles in the valley of the Till. This district consists of gentle undulations, having for the most part a cold stiff soil, difficult to work as arable land, and not good for pasture in summer. At Carleton-le-Moorland it is generally a fertile hazel loam. At Beckingham the pastures near the river Witham are excellent feeding grounds; and about Claypole, though much is very low and wet from floodings of the same stream, the soil is very strong and excellent bean land. Long-Bennington has a surface of strong clay, and this rests upon strata of limestone and freestone. The lias extends to the western boundary of the county to the southward of Beckingham; eastward it is bounded by the Heath hills, or rather by a narrow belt of land at the foot of those hills. At Leadenham commences a ridge of high land in front of the Heath, similar to that at the northern extremity of the formation, which, running in a south-western direction, forms the base of the lofty hills of Hough, Great Gonerby, and Barrowby, being a very heavy and tenacious clay soil. In the parish of Honington the clay is of a milder character; and over the whole tract the soil varies much in its texture, according to the subsoil and the nearness of stone to the surface. A breadth of 6 or 7 miles of the lias is here within the county, and its most southern limit is near Woolsthorp and Belvoir.

The *Oolite* rocks are next in succession, occupying a considerable portion of the county. They form a ridge of hill which, commencing at Wintringham, near the Humber, and running almost parallel with the lias hill as far south as Manton, presents a bold escarpment towards the valley which lies between. The lias hill gradually loses its elevation as it advances southward, but the oolite range continues through Kirton, Lincoln, Leadenham, and Grantham, presenting a lofty baset-edge to the west, and, with the exception of a single break near Lincoln, completely separating the broad valley already noticed from the rest of the county. North of Lincoln the breadth is inconsiderable, being a single ridge sloping gently to the east, and dividing the Trent valley from that of the Ancholme; but south of that city the hills gradually expand, having the valley of the upper part of the Witham on the west, and that of the lower part of the same river (which trends round in a singular manner) on the east; and the southern portions are diversified with numerous hills and watered vales. The Lincolnshire oolites may be thus classified:—

Name of Formation.	By what Groups represented.	Nature of the Beds.
Upper oolite . .	Kimmeridge clay . . .	Blue clay with shales.
Middle oolite . .	Oxford clay	Blue clay with sands, shale, and coal.
	Kelloway rock. . . .	Calcareous sandstone and grit-stone.
Lower oolite . .	Cornbrash	Coarse limestone.
	Great oolite	Limestone, compact or sandy.
	Inferior oolite	Yellow limestone with veins of ironstone.
	Calcareous and ferruginous sand.	White and red sand and sand-stone.

The hill range is composed chiefly of the five latter beds, which, running in parallel strips, cause frequent and sudden variations of soil in the upland parishes. In the neighbourhood of Winterton and Roxby is a rich yellowish soil resting upon grey and yellow limestone, apparently of the inferior oolite, and extending to High and Low Risby and to Appleby; it is impregnated with iron, and forms a good friable loam, adapted to almost every kind of crop. Eastward of this, and lying between the limestone and the alluvium of the Ancholme flat, is a narrow band of grey sand upon sandstone, being (it is believed) the Kelloway rock, which dips eastward under the Oxford clay and incumbent marshes. The sand which probably forms the lowest of the oolite beds appears on the west side of the hill, in the valley between the two ridges before mentioned. It commences at Normanby, and stretches eastward over the hill to Appleby, Broughton, and Twigmoor, and southward to Flixborough and the eastern parts of Crosby, Frodingham, Ashby, and as far as Kirton. This sand seems to join the Kelloway sandstone south of Appleby, forming a broad tract of light blowing sand, of various degrees of inferiority; in some parts so sterile as to be incapable of growing anything except a white moss, and in other places covered with plantations. At Whitton, and on the hills between Winterton and Kirton, occurs also the gritstone, and shale abounding with ammonites and other fossils. About 3 miles north of Kirton the great oolite arises, and runs due south to Lincoln, acquiring from its steep western face the name of "Cliff." The rock consists of thick beds of limestone with perpendicular partings, and is covered with a soil of sandy loam. The east side of this range has a brown sandy limestone, and the soil is thin and light; but between the Lincoln and Brigg road and the brow of the hill the rock is a blue limestone (yielding 96 per cent. of lime), and the land is deeper and better by many shillings per acre rental. It is a good turnip and barley soil,

and will produce wheat of good yield and quality. On the steep western slope the soil is fertile and good: at the base of the hill, and extending a short distance in the vale, there is a narrow line of pasture upon a rich clayey loam, probably a talus formed of the debris washed from the hill. Beyond this is a band of red soil under arable culture—a deep sandy loam without stones, apparently a rich soil for 1½ feet in depth; but though it will produce an immense bulk of corn the grain is of very bad quality. This appears to rest upon the inferior oolite. West of this is a rising tract of good land, which again sinks into the clay valley. It belongs apparently to the lias; there is not much of it under grass, and it does not make good feeding land. Southward of Lincoln, for 15 or 20 miles, extends the "Heath," a ridge of the great oolite rock, probably about 250 or 300 feet in height, and having a gradual descent eastward. The soil is generally a good sandy loam, with clay enough to render it slippery with wet; but it may be worked in almost any weather, being a free-working, fertile soil, and easy to manage. It is often thin, loose, and dry, approaching in the eastern parts to a fawn-coloured sand about 6 inches in depth; but the usual depth varies from 9 to 18 or more inches. The whole Heath district is arable land, producing large crops of green food, barley, and wheat. The soil is always dry, as the water sinks through the fissures in the stone until it meets with a bed of clay, when it issues in springs of great volume and rapidity,* originating the rivulets which flow downward to the Fens, and keeping the surface of the lias continually wet with their flow. The breadth of the great oolite is here from 4 to 7 miles, and the eastern portions, which chiefly consist of bluish limestone, dip under the Oxford clay and drift deposits between Lincoln and Sleaford. The inferior oolite skirts the western declivity from near Lincoln to Honington and Belton, forming a good red deep loam with fragments of stone (locally termed "creech" land) and a light sand. In the valley which intersects the cliff at right angles from Honington to Ancaster, the same bed crops out, having a surface varying from a very light sand to a loamy sand and to creech. Through Barkston, Belton, and other parishes, the red land is remarkably rich, lying upon the slope of the great oolite hill, and between it and the range of strong clay on the west. The abrupt hill of great oolite passes by Grantham, Harlaxton, and Denton to the boundary of the county: the inferior oolite swells into lofty irregularly-shaped hills about 2 miles distant from it, passing by Barrowby and Woolsthorpe to Belvoir, or rather caps these hills

* At Stoke-Rochford, near Colsterworth, on the great oolite, is a spring which throws up nineteen tons of water in a minute. At Braceborough, near Lincoln, a spring issues seven hogsheads per minute, and there is an abundance of similar instances.

formed by the lias. East and west of Hough village it is a deep red soil of rich quality; and the higher lands of Great Gonerby parish are the best description of red land. Barrowby hill is the same, enclosing a winding valley of the lias clay which runs on both sides of the Nottingham canal up to Grantham. The clay which forms the low lands in both Gonerby and Barrowby is very strong, but of productive quality. The soil on the hill at Barrowby is a deep red loam resting upon a yellow and ferruginous freestone rock; at Woolsthorpe it is a rich red sand, and all along the edge of the vale it is generally a sandy loam mixed with stones. These outlying beds of inferior oolite abound in iron, of which there are veins in the shape of dark red ironstones. The lordships of Barrowby and Honington are said to rival each other in the richness of their soil; but Barrowby may probably be considered as the most fertile parish in Lincolnshire, producing vast crops of wheat, barley, and oats, fine turnips, and (like the land at Belton, &c.) large trees of beech, lime, ash, &c. The great oolite occupies all the south-west corner of the county, and is bounded on the east by a line drawn from the neighbourhood of Sleaford to Corby, and thence to the shire boundary near Uffington. It is generally a white limestone, but on the east, from Quarrington to Ingoldsby, it changes to a hard blue stone, which is both burnt for lime and used for repairing roads. Near the town of Sleaford the cornbrash appears upon the surface, and is found stretching away southward in a narrow band to the vicinity of Tallington, near Stamford, having its greatest breadth between Corby and Edenham, about 4½ miles, dipping pretty uniformly eastward, and always entering under the Oxford clay. The widest part of both these beds of limestone taken together is from Edenham westward, about 10 or 11 miles. This tract comprehends various strata of fine and coarse limestone, with clay partings between the beds, having a covering of tenacious calcareous and argillaceous soil, often mingled with slaty fragments of the rock on which it rests. This soil is of good quality when dry, producing beans and wheat, and is yet not too strong for turnips. Between Grantham and Corby is much cold wet clay, but a great portion of this rests upon deposits of drift; and the remainder is a dry and fertile sandy earth upon the white limestone rock. Much of the eastern portion of the oolite district in the neighbourhood of Folkingham, Osbournby, &c., has a soil of "creech"—the name applied here to loam on stone, a stiff, wet, stony soil, very dirty in winter, but when well under-drained forming productive land. Between Corby and Edenham, and southward, the soil varies from clay to creech and sand; the creech making good arable land, and the clay being in some places good, but much of it cold, wet, and poor. On the coarse,

dark-coloured limestone the soil is often very thin, and principally composed of minute fragments of the rock.

The *Oxford and Kimmeridge Clays* are not separated in Lincolnshire by the coralline oolite, or calcareous grits, and therefore form one thick bed of clay, the boundary between the two being undistinguishable; and the principal part of their surface is buried under deposits of drift and the alluvium of the Ancholme level and southern fens. A narrow line of it is found along the foot of the hill east of Kirton-in-Lindsey, lying between the high land and the Ancholme carrs. It is called the "Carr heads," and forms a stiff clay soil, bad in quality. This extends southward to the river Witham, through Cold Hanworth and Sudbrooke, being a cold clay, very narrow, and bounded east by the detrital deposit of the central valley. On the south-west side of the Witham fens it is interspersed with the beds of drift, occupying a small portion of the surface in the parishes on the lower range of hill east of the heath. The soil varies from a mild friable loam to a very tenacious clay. This extends to Timberland and Billinghay, where it forms a bold promontory of high land advancing into the fen, and beyond it toward the south (through North and South Kyme) it forms an island of high ground rising out of the fen-land; but the clay is frequently hidden by deep layers of transported earths. In the district south and east of Sleaford, by Scredington, Osbournby, &c., it is a stiff clay, harsh, and difficult to work; and through Burton-Pedwardine, Helpringham, Swaton, and other parishes, the strong clay land continues. From near Folkingham to Edenham and Bourn it is a close, heavy, compact clay, producing beans, wheat, oats, and clover, and much of it is under grass. At Kirkby-Underwood it forms beautiful pasture-land, dry enough for sheep, and rich enough for horned cattle. Along its whole course this bed dips under the fens, and exhibits an undulating surface of but trifling elevation. From Bourn to Thurlby, &c., it is a various soil, probably owing to the alternating layers of hard sand and clay of which it is composed; much of it is poor land, and the pastures are very subject to parching in hot summers. East of the Ancholme flat the clay runs in a low ridge from near Brigg through Cadney and Kelsey, Owersby, Kingerby, &c., being a very strong but fertile soil, and forming excellent pasture. It is very narrow, and, sloping to the east, underlies a broad flat tract of sand that stretches between it and the Wolds. This is probably the Kimmeridge clay, but it is difficult to distinguish it from the Oxford clay, as the stone band (viz. the coralline oolite), which has its place between these beds, thins off and disappears in its course northwards from the midland counties. These clays form a mass of enormous thickness, which, it is be-

lieved, has never yet been sunk through, and spread out to a great breadth between the Wolds and the Cliff and Witham Fens. A line taken at right angles to its course is about 15 miles in the widest part, probably its maximum of superficial extent in this kingdom. This tract is extremely low, scarcely exceeding in height the fens which cover its other portion. It is to a large extent hidden beneath thick beds of drift, principally the white clay called "chalk breccia." The clay itself is generally barren and intractable, a heavy outlay of capital being necessary in order to farm upon it with success.

The cretaceous system of rocks exhibits an arrangement different from that which has been observed in other parts of England, particularly as regards the green sand formation. The following is the order of the beds :—

Name of Formation.	Thickness in Yards.	By what Beds represented.	Nature of the Rock.
Chalk.	100	Upper chalk	Soft chalk, with flints in layers.
		Lower chalk	Harder chalk.
	2 to 4	Red chalk.	
Green-sand	6 to 10	Quartzose ferruginous pebbly sand.	
	12 to 14	Calcareous clay, containing beds and concretions of oolitic limestone.	
	Considerably thicker than the two former beds of sand and clay.	Granular quartzose sandstone and sand, varying from dark brown to light grey, and containing shells.	

The *Green sand* first appears upon the surface near the town of Brigg, and thence continues southwards in a narrow strip in front of the chalk. West of Caistor, and extending towards Market Rasen, it is a wide flat moor of sand, wet with the brooks from the Wold hills. The surface varies from a red gaulty sand to a black peaty sand, altering at almost every chain. Under grass it is dark with vegetable matter from the decaying root-fibres; when ploughed, it is a loose red or black earth, the furrow-slices grey with veins of white sand. Underneath, 4 to 6 or 8 inches of the surface-soil is a rusty sand, sometimes cohering together like soft sandstone. In Nettleton Common this is about 30 feet in depth; and the whole reclines upon blue clay, which dips under it from the west. Some parts of it are light blowing yellow sand, drifting out of one field and forming a hillock in another. It is probably by the agency of wind, and perhaps also of water, that the surface generally has become so level, much of

it having been drifted apparently from higher ground. The portions not cultivated are under plantations or gorse. Between this low sand and the chalk rises a bold range of hills in precipitous slopes and successive projecting ledges, consisting of a foundation of the variegated soft sandstone surmounted by the red clay with its concealed beds of buff-coloured limestone. Doubtless this cliff-like contour was occasioned by the upper stratum ("like a stone coping on a mud wall") having defended the lower from the attrition of water. The line of hill extends from Nettleton southward to Claxby, and the red land is also found northward at Grasby and Bigby as a deep and rich reddish-brown strong loam under grass, and southward from Claxby through Normanby, Walesby, Tealby, and Brough-on-Bain. The surface presents an aspect of dark green in contrast with the chalk hills, the pastures being rich and plentiful. This land, however, is only a narrow strip, skirting the western escarpment of the Wolds, through Scamblesby, &c., as a low vale of red sandy clay; and it is in this valley that efforts have been made to obtain some of the far-famed coprolites, hitherto without success. The sandstone rising into hills widens out as it passes in a south-eastern direction; Belchford, Salmonby, Hagworthingham, Harrington, Raithby, &c., are on its course. The soil is both siliceous and calcareous, friable, rich, and productive of every kind of crop, especially turnips, wheat, and barley. The clay is found only as a narrow band at intervals between Salmonby and Spilsby, principally west of the latter town. A few feet from the surface of this clay is found the ragstone, not as a solid rock, but divided into small irregular stones. The clay itself is stiff and sticky, of a yellowish or red colour, with veins of blue clay. Red metallic concretions, termed "iron-mould," abound in it. Particles of the green sandstone are intimately diffused throughout the mass, and it is probably this which causes the soil to be a rich free-working loam instead of a hard unmanageable clay. It contains much iron, and is of far more value and fertility than the sand-land adjacent to it. The hills that look over the fens from below Halton-Holegate to Toynton, East and West Keal, and Bolingbroke, are composed of green and ferruginous sand and sandstone; the soil being generally a good sandy loam, sometimes a thick brown loam with flints, but frequently only a thin covering of earth upon a coarse quartzose sand and greenish red sandrock. This land has been furnished by nature with a ready means for increasing its productiveness: in the deep valleys which penetrate it in all directions blue marl or clay is found, and is of great value in giving strength and consistency to the soil. Masses of white marl, or drift, are also found upon its surface. The dark-blue "buttery" clay contains large and small slabs of shale which abound with ammonites and various

fossil shells, and is undoubtedly the Kimmeridge or Oxford clay laid bare wherever the green sand has been eroded to a sufficient depth by ancient floods.* At Hareby, where this clay crops out from beneath the sandstone, large pits of it are excavated, and it is applied to the land with the most useful results. It occupies a space between the foot of the hills and the alluvial deposits of the fens, and valleys of it open up into the hills from Hagnaby to Bolingbroke, &c., and from Steeping to Ashby, Partney, &c. In the latter valley the marl crops out half way up the hill side, covered by the green sand strata, and along the bottom it is hidden under a few feet of coarse granular sediment mixed with mud from the floodings of the Partney river,—evidently the debris of the hills washed by numerous rivulets into the stream, and by it deposited in horizontal meadows on each bank. The breadth of the green sand formation is inconsiderable, except in the southern parts, where, between Langton and Bolingbroke, it is $4\frac{1}{2}$ or 5 miles.

Unlike these hills, with their steep red fields, their sombre woods, and dark green pastures often rough with furze, the Wolds ascend with naked dull grey acclivities to a loftier elevation, and their baset-edge extends in one unbroken line for many miles. The sand generally reaches for some distance up the slope, and midway along the face of the hill the band of red chalk is observed shining pink through the scanty herbage, and at times may also be seen dotting the brown fallow fields with ruddy heaps of stone. The *Chalk* hills range from Barton-upon-Humber to Gunby, a distance of 45 miles, having an average width of about 6 miles. The broad chalk district at the northern extremity of this line appears to be entirely sundered from the rest by a deep valley of clay between Brigg and Ulceby, but from Melton-Ross, southward, is an uninterrupted succession of chalk hills and winding vales, expanding to a breadth of 8 miles in the central portion, and gradually tapering to a point at the southern termination. The red chalk, which probably derives its tint from the presence of a small quantity of oxide of iron, runs along the whole length of the formation; but as its thickness is merely from 6 to 12 feet, and as it always crops out on a steep slope, a very small proportion of the soil rests upon it. This seam or stratum, being at the base of the formation, generally lies upon a bed of sand, and when sinking a well upon these hills this bed must be pierced before water is found. At Caistor, midway up the ascent, the band of red chalk rests immediately upon the red clay and oolitic rock of the green sand, which throw out numerous fine

* In many parts of the clay district borings have been made with a view of obtaining coal, but of course without reward; the bituminous shale which abounds in the clay having deluded many persons into the belief that fuel may there be found.

springs. The lower chalk rock underlies probably about half the surface of this district. The pits show a considerable thickness of rubbly chalk above the regularly stratified and fissured rock, and between the two there is often a seam of clay, or yellowish marl, 1 or 2 feet in thickness. The upper chalk, occupying the eastern side of the Wolds, has horizontal layers of flint at every 6 feet downwards, each layer being from 4 to 8 or more inches thick.* The soil upon these two strata of chalk is nearly all of the same character, except where local beds of drift occur, and the main difference seems to be that the land is naturally warmer on the west than on the east side of the Wolds. The soil is a sandy loam, containing flints and fragments of chalk in more or less abundance, the open and permeable nature of the subsoil rendering it perfectly dry in summer and well-drained in winter. It naturally produces a short good herbage for sheep, but its capability of yielding roots or grain under arable culture depends entirely upon the treatment it receives. The quality is exceedingly variable: some land still continues a thin coating of light sand, other parts have become deep fertile flinty loams,—some of the rich friable lands producing fine crops of barley and wheat, and other portions (particularly in the valleys) forming excellent pasturage for sheep and breeding cattle. The *Plastic clay*, lying on the dip side of the Wolds, appears to cover the hills to some extent with a thin stratum of red flinty clay or brick earth. This deposit is found to be deeper on the eastern slopes of the different hills than on the west, and with such a dry subsoil as the chalk rock forms a most useful description of land, calculated to grow any kind of grain in abundance. It varies from 1 to 3 feet in thickness.

The formations above the chalk in both Lincolnshire and Yorkshire have not hitherto been satisfactorily explored, and have been too hastily considered as entirely concealed by alluvial or diluvial deposits; but from various facts it appears that this is not universally the case, and that the regular tertiaries may be observed, though separated from the main tract of the London basin by the estuary of the Wash. It seems also that the clay strata of that basin, which die away above the chalk in Norfolk, are again present in Lincolnshire. Eastward of the Wolds is an undulating tract of country sinking gradually towards the sea, and stretching from Barton north to Firsby south, with a breadth of about 5 miles. It has been named "the clays," or "middle marsh," as it consists of heavy land midway between the hills and salt marsh. The soil of Holderness in Yorkshire (somewhat similar to this)

* The chalk is too soft to use for building purposes, and is employed as a foundation for roads. The lime obtained from it is fit only for the land, and for that purpose is not so strong and good as lime burned from Yorkshire stone.

has been described as mainly consisting of diluvial deposits,* but the stratified beds have also been found there, for on boring through the alluvial lands a stratum of sand is met with immediately beneath them; this rests upon a bed of clay, which finally reposes on the chalk. These beds are undoubtedly the lower members of the plastic clay formation, being disposed horizontally, while the chalk below dips slightly to the east 5 yards per mile. This has been mentioned as a confirmation of the following statements respecting the very similar tract in Lincolnshire; the two districts being divided merely by the denudation of the Humber. As the chalk dips under the clays and marshes great numbers of wells have been sunk down to it in order to obtain good water with little trouble, and the purest fresh water rises plentifully through the borings to the level of the surface. In some localities, indeed, there are natural shafts called "blow wells," as near Tetney, which furnish an unceasing supply of water from the chalk beneath. The beds of alluvial deposit and of the clay have thus been penetrated at many points, and their nature and depth made known. The clay, which has many sand-beds in it, is generally of a reddish brown colour, containing small pebbles, and resting upon a bed of flinty gravel. Its thickness increases from a few feet near the edge of the chalk to about 20 yards where it underlies the marshes; and near the sea-bank at Saltfleet, Sutton, and other places, it is about 13 yards from the surface. At Steeping, near the southern extremity of the tract, the clay lies upon a bed of white gravel, which is at least 20 feet thick, and possesses springs of water. Between Firsby and the chalk-hills this clay is 12 or 15 feet thick, resting upon gravel; and in the lower part of the parish passes under alluvial deposits, from which it is separated by a stratum of sand. At Braytoft and Gunby, 1½ miles from the chalk, are found under the clay beds of gravel worn by trituration like shingle; and at Burgh the clay is about 4 feet in depth, lying upon a seam of red sand, under which occur flints for a considerable depth. At Welton and Boothby a small tongue of red sandy land runs eastward from the chalk-hills; it lies upon gravel and abounds with small stones. About Well and Alford is a large plot of flinty gravel, two-thirds of it being pebbles of chalk; and at Legburn and Louth similar beds occur, the clay above being from 2 to 10 or more feet thick. Under the marsh at Sutton the clay has been found reposing upon gravel, which had springs; and in wells, in the marshes between Louth and the coast, the alluvial deposits rest on sand, which overlies a bed of clay containing various kinds of earth. At Little Grimsby is another deposit of gravel, very deep, and composed chiefly of white chalk pebbles.

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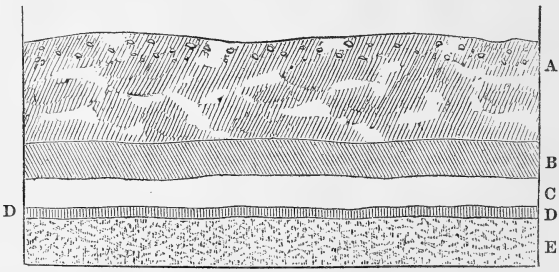
* Journal, Vol. IX.—"East Riding of Yorkshire."

The clay is generally red, but at Little Grimsby and Grainsby it is blue, very hard, of considerable depth, and containing many small pebbles. At Fulstow the clay likewise possesses beds of gravel. At North Ormsby the chalk dips under this district, having a bed of flinty clay upon its slope, covered by the stiff brown clay free from stones, which there commences in section like a wedge—deepening towards the east. At Riby the chalk disappears under gravel, which is excavated at the neighbouring village of Aylesby, and this is covered by the sand and brown clay. At Great Limber the chalk sinks beneath the clay, and here a brick-yard exhibits a deep section. The clay over most of the district usually burns to a brown-red brick; here, however, it is made into ornamental facings, "string-course bricks," &c., having exactly the appearance of stone. The beds are thus disposed:—



A. Stiff brown clay, at least 16 or 18 feet thick, with veins of sand or silt, and pebbly near the top. It burns into a beautiful white pottery resembling sandstone.
B. Two or three feet of bluish wet sand, very much like sea silt.
C. Strong slate-coloured clay—the bottom portions laminated.
D. A thin bed of indurated reddish clay or shale, named the "iron-pan."
E. Very fine dry yellowish sand.

From Limber to Melton-Ross the clay sometimes forms only a thin coating upon the chalk, containing chalky fragments; and in the valley which runs east and west from the latter place the chalk is seen rising up on each side from under the same clay, which seems to run in a narrow band towards the Ancholme valley. At Barton the same order of position is observable,—the clay ascending for some distance up the Wold acclivities, gradually lessening in thickness as it rises, and extending in patches of deeper soil upon the hills. A comparison of all these statements will show the regularity of the series of beds which are not, therefore, members of the Northern Drift; and the general constancy of the descending order of—

a. Sand,
b. Clay,
c. Gravel, flinty, with springs,

seems to identify this formation as the *plastic clay.** The above

* We are unable to say what is the evidence of fossil remains upon this point.

details would not have been given, had not the supracretaceous deposits of this county been either unknown or confounded with the drift and alluvium which form a part of them. The soil is generally a strong heavy clay or a loamy clay. In the southern portions it is very stiff and retentive; between Hogsthorpe, Huttoft, and Alford, &c., where numerous round knolls or hills of the clay rise up through the crust of marsh land, it is a brown loam on a clay bottom, or else a superior free-working clay. North of Louth the soil is close, adhesive, and wet; there are surface variations, but the general tract is naturally cold and poor. From Grimsby to Barton is a strong clay and a reddish-brown loam of productive quality; and between this and the chalk is a belt of more friable land,—deep, fertile, and good.

In this county there are extensive deposits of the sand, gravel, and other materials which, occurring upon the surface of the older stratified formations, have been denominated "*Diluvium*," or "*Drift*." The currents of the great Northern Drift, which swept the Cumbrian boulders and other erratic detritus along the vale of York and over the chalk hills to Holderness and the Humber, appear to have shaped the present surface of Lincolnshire and the fens by their denudation of the strata, and by heaping the transported matter in various directions to a great thickness. The lowest member of the drift, viz., blue or brown clay, containing nodules of chalk and large blocks of stone, which overspreads wide spaces of the Oxford clay and other strata in the southern fens of Cambridgeshire (probably carried thither by the floods that burst the barrier of chalk hills and formed the present Wash estuary), is not widely distributed over the same valley in Lincolnshire; having been found only in a few localities upon the borders of the Witham fens, and as a strip of high land stretching northward from Sibsey, dividing the east and west fens. It is occasionally met with east of the Wolds; and in sinking wells, masses of chalk have been found lying upon the bed of plastic clay. In the brickyards below Louth the boulder clay is laid open; the top soil is a brown clay, with layers of chalk nodules and flints, at from 1 to 4 feet depth; and under these are brown and blue clays, very hard in some places, in others changing to a soft whitish marly clay with similar chalk detritus beneath it. Boulders of the primary formation occur, and also beds of yellowish sandy shale and sandy earth. On the chalk hills are several local beds of drift. Between Welton and North Ormsby (west of Louth) are two hills composed of large irregularly-shaped reddish flints among veins of red and black sand, from 1 to 20 or 30 feet thick above the chalk; and between Kelstern and Binbrook are deep deposits of gravel, red sand, and large flints. At Hagworthingham is a bed of ferruginous flinty gravel, a coarse drift

with rounded and white flints; and there is another deposit at Partney. These gravels and sands may, however, be outliers of the plastic clay. The most extensive tract of drift is that which extends itself from the Ancholme flat to the fens at Tattershall, a length of 25 miles; and from the green sand district to the Witham fens, a breadth of 10 or 11 miles. The Oxford or Kimmeridge clay is here covered in nearly every part by a great thickness of transported earths, forming three different kinds of soil. The northern and western portions of the district about Wragby, &c., have generally a surface of clay, not very strong, but producing corn of good quality,—resting on a subsoil of mixed clay and sand, or gravel, or, where that is not the case, white marly clay. Approaching the Wolds, the white clay (or chalk breccia) is at the surface, resting at a considerable depth upon the Oxford clay, and at its eastern edge capping the hills of green sand—that formation occupying the valleys as a red or brown sandy clay containing flints. It is a white greasy marl, containing flint stones, large blocks of chalk and flint, and rounded pebbles of chalk in great numbers. It is generally absent from the valleys, but attains to a considerable thickness on the hill summits. Marden Hill and Hundleby Wood, to the west of Spilsby, are two green-sand hills capped by deep deposits of this chalk drift; they are about 1½ miles apart, and some distance from any larger bed of the clay. At Hareby, where it hides both sandstone and blue clay, it is found of various depths, from a thin coating of a few inches to a deposit of more than 14 yards in thickness. This clay forms a most valuable material for applying to the sand land, and is also burnt for lime. Like the chalk, it effervesces with acids, and yields a large percentage of weak lime, the marl burning into powder. The soil upon this kind of drift is wet and sticky, and much of it is very poor in quality. The southern part of the drift district has generally a sandy soil resting upon gravel. The Tower Moor, east of the Witham fens, has been partially and with difficulty reclaimed from natural sterility, many parts of it producing nothing but stunted furze and ling. The gravel is there about 12 feet deep, upon the Oxford clay. At Tattershall, upon the sloping grounds that rise up from the fen, 4 or 5 feet of fine gravel conceal the same clay. From Tattershall through Coningsby, Tumby, Mareham, Revesby, &c., the same sandy gravel forms the surface, except in those places where the clay is left bare. In these and neighbouring parishes there is everywhere plenty of water, which breaks out of the hills in springs, and these, if not cut off, find their way into the fens below. The hill behind Revesby Abbey, rising gradually to an elevation of 140 feet above the fen, consists of "coarse Norfolk marl," from

11 to 13 feet thick, upon the solid blue Oxford or Kimmeridge clay, here dipping under the alluvium of the fens. The rain which sinks into the hill descends upon the sloping surface of the clay, working its way gradually through the permeable stratum above it, and standing in that stratum at a higher or lower level according to the wetness or dryness of the season. The hill extends for several miles, with a similar order of strata, the water sinking to the fen catch-water drain.*

Upon the opposite side of the Witham fens the drift is found in the shape of light sand and gravel, overspreading more than half the surface of the Oxford clay. In Blankney parish it is a black hungry gravel, but varies to light siliceous sand and gravel. At Ewerby it spreads down into the fen, being a red sand. Deposits of calcareous gravel occur in the valley at Edenham and other places near Bourn, resting on the edge of either the oolite or Oxford clay; and at Baston and Deeping there is an extensive bed of gravel having a sandy surface-soil, which widens out, dividing the fens from the oolite limestone hills. The drift waters, which appear to have been precipitated over this county from the east or north-east, found an obstacle to their progress in the oolite ridge; and at Lincoln they seem to have torn a passage through this barrier, depositing in the lias valley beyond a mingled mass of gravel and sand. At Doddington, Eagle, &c., the soil is a gravelly loam; and southward are found large tracts of moorland upon these barren deposits of drift. An extensive bed of calcareous gravel amongst a yellowish red sand is the subsoil north-east of Sleaford, towards Ruskington, Dorrington, &c., the surface being a good loam, sometimes of considerable depth, and sometimes with the sandy subsoil near to the top. From Sleaford to Wilsford the soil is sandy, upon a deep deposit of light-yellow gravel. The same stratum on the surface changing more to a red sand, seems to turn southward toward Grantham, on the east side of the Witham, dividing the red oolite soil from the lias clay, and is doubtless of a similar nature and origin to the gravel with loamy covering found under the cliff northward of Lincoln. At Grantham the soil is a strong reddish brown clay, slippery with wet, resting at 2 or 3 feet depth on a whitish and yellow gravel mingled with a yellowish earthy sand,—similar, indeed, to that in the neighbourhood of Sleaford. Along the Witham valley, between Grantham and

* Advantage has been taken of this abundant water for a useful purpose: on the other side of this hill, at Miningsby, a reservoir of about 20 acres area has been constructed, which, by means of an aqueduct of iron pipes, supplies the town of Boston with water. This town had fruitlessly sunk bores through the subjacent alluvium and Oxford clay in search of the Oolite rock, and this reservoir, elevated about 125 feet above Boston, now sends beautiful fresh water through piping (laid alongside the Spilsby turnpike road) upwards of thirteen miles in length.

Colsterworth, is a considerable bed of drift, a clay upon gravel, the gravel obviously being rounded fragments of the yellow or oolitic limestone. This deep deposit, in some places a red sandy clay upon a dark-coloured gravel, also occupies the hill slopes occasionally in round knolls. Eastward from this valley there is a broad tract of cold heavy clay, though changing to a sandy soil, and a brown clay upon a whitish marly clay,—doubtless deposits of drift; and beds of gravel lie in various parts of this limestone district, as, for instance, between Corby and Edenham. In the vicinity of Osbournby the drift clay is of a loamy nature with gravel at 3 or $3\frac{1}{2}$ feet depth. In the north of the county the detrital deposits are likewise present. About a mile west of Ferriby Sluice rise 2 or 3 mounds of gravel, extending toward Wintringham. At Whitton is a remarkably interesting section: the village rests upon a bed of gravel many yards in thickness, disposed in layers of from 2 inches to 2 feet each. Each layer is composed of stones of one particular size, varying from those as small as wheat to some as large as a man can lift,—not arranged horizontally, but at several degrees of depression. Gravel of a similar kind presents itself at Wintringham and Flixborough. Flanked by the two ridges of hills which mark this part of the county, and lying between the light sand and the Humber, at Thealby, Coleby, and West Halton, is a red soil upon dry gravel, producing first-rate crops. The soil at Whitton is sand, of excellent quality, growing turnips, barley, and good wheat. In the Isle of Axholme, on the high lands, are also found local beds of gravel.

The *Alluvial* formations must now be described;—which is a work of some difficulty. Investigation into the nature and origin of alluvial deposits is somewhat analogous, we imagine, to the study of diseases of the skin: "pathologists," it might be supposed, "might surely discover more respecting the outside of the body than concerning affections of the viscera," yet, such is the multiplicity and similarity of cutaneous disorders, that the contrary is the fact; and in the same manner, so closely do many alluvial, drift, and tertiary beds resemble each other, that less information seems to have been collected regarding the very skin and outer integuments of the world than of the older aqueous and volcanic rocks. But the alluvial strata of the Great Level of the Fens are of peculiar interest to geologists,—the peat beds and tidal deposits offering an approximative means of deciding the *date* of the great Northern Drift.* Comparatively little has

* The Roman embankment all along the coast stands upon ground which has been covered with several feet of tidal accumulations since the bank was built; and Roman roads cross the Fens, laid upon peat, and yet overgrown by peat since they were constructed: these historical works constituting integers in a scale of years by which the

been made known respecting the soils of this district, and a great variety of facts have therefore been collected for the purpose of attempting here to elucidate the structure and origin of the fens, of which details only the general results can be brought forward at the present time.

The Oxford and Kimmeridge clays form the great pan on which the alluvial accumulations principally rest, — not only dipping under the fen lands from the north and west, but in many places (as March, Whittlesey, Thorney in Cambridgeshire, and Kyme in this county) swelling up through them in the shape of low hills, generally covered by thick deposits of gravel or brown drift clay. This great bed of clay, with the incumbent sand and gravel, rarely forms the surface or immediate subsoil of the flat land, except near the high lands, but undulates beneath the fens, being much further from the surface in some localities than in others. At Boston, 11 miles from the western hills, where the Oxford clay descends, it is found at the depth of about 38 feet from the surface. The unevenness of its surface is undoubtedly the effect of denudation by water; and it appears to have formed the bed of a spacious bay, on which have accumulated the alluvial beds,—raising the surface up to one uniform level. The subterranean gravel might be supposed to have been washed into this bay by the ordinary action of the tides, were it not connected with similar beds upon the neighbouring uplands and the "islands" in the fens, at an elevation far above the reach of the present oceanic waters. The first or lowest of the alluvial deposits appears to be silt,—a wet muddy sand, hard and blue at its greater depths, softer and whiter in its upper portions. This does not extend under the whole of the fens, but it has been found below all the other alluvial beds. It is evidently the ancient bottom of the great bay, having been a wide expanse of irregular sand-banks like those which are now choking the existing estuary. It is laminated in its upper parts, thus exhibiting a tidal structure, and abounds with cockles and other marine shells. The silt seems in some places to have been accumulated on a shore, and elevated into mounds or ridges like those upon the coast at Skegness and other places, where the sand is drifted by the winds into hillocks above the flow of the tides, and bound into a compact mass by the creeping roots of the *arundo arenaria.* It is thus found piercing the super-

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age of the various deposits above the drift beds may be computed. Between the alluvium and the older strata occurs an immense subterranean forest, with trees standing as they grew upon ground many feet lower than the sea at high tide; a circumstance apparently indicating a comparatively recent alteration in the relative levels of land and water, which will explain the phenomena of similar submarine, &c. forests (more modern than the drift) on many parts of the coast of Lincoln, York, Norfolk, Kent, Dorset, Somerset, &c., &c.

stratum of clay in the southern parts of South Holland (Gedney Hill, &c.), and in Cambridgeshire (Wisbeach St. Mary's, &c.), running in veins or ridges a few feet higher than the surrounding fen, and, at times, scarcely a quarter of a mile in width. In some parts of the level, where this silt is absent, occurs a stratum of peat from 1 to 3 feet thick, resting upon beds of drift. In the Witham fens, west of the river, this moor, one foot in thickness, containing branches of trees, rests upon a bed of sand 1 foot in thickness, beneath which is the Oxford clay; and near Bardney, where the same clay rises up from under the fen, the peat stratum is near the top, and in it have been found immense trees of oak and fir, their roots standing upon a thin bed of sand, and striking downward into a bed of blue boulder clay. The same peat is found about 2 feet below the surface of the fens east of the Witham, probably dipping under Wildmore, &c. fens. It has been found at Boston about 20 feet from the surface, resting upon sand, gravel, or stony clay. The moor is several feet lower than low-water mark, and therefore there must have been a considerable change in the level of either land or sea since it was formed.

The next bed in the series is the soft blue clay, which is found almost everywhere under the peat fens, and seems to be the muddy sediment left by stagnant lakes and sluggish rivers. This clay, varying sometimes to a red clay (as in some parts of Deeping Fen), or a whitish silty clay (as in the Witham fens), extends throughout the greater part of the level, and must have been subject to the overflowings of the tides, for channels of creeks with banks of raw silt exactly like our present salt-water marsh creeks are found intersecting it; and in almost every part of the fens veins of silt (apparently the warped-up courses of creeks) may be traced within it in nearly every direction. Sea-shells are not abundant in the clay, but lie plentifully in the silt veins and on the surface of the clay. From the fluviatile and fresh water shells which are contained in it, and in the peat which overlies it, the water from which it was deposited appears to have been partly salt and partly fresh: indeed from the numerous old river channels, shallow and circuitous, which have been choked up and dried within the historic period, it is easy to form an idea of the number of wandering courses the fen rivers must have formed for themselves, when pouring down in swollen volume from the hills into a wide horizontal plain, where every direction offered equal facilities or hindrances to discharge. These channels, by diffusing the waters, lessened their force and momentum seaward, and consequently the slightest impediment or tidal bar could stop the stream, change the current, and produce an inundation. Each bend in the tortuous channels re-

tarded the motion of the water, thus causing a deposition of sediment which raised the beds of the rivers, and precipitated them over the level. This clay, in the vicinity of Lynn, rests upon "till," or boulder clay; and with an incumbent bed of peat underlies a great part of Marshland in Norfolk, and where the marsh alluvium ceases widens out for many miles, forming the peat fens and clay subsoil of the Bedford Level. It has occasionally two strata of peat, 2 or 3 feet apart (as in Sutton St. Edmund's parish in South Holland, in the vicinity of Lynn, and in some of the Huntingdonshire fens). It is found beneath the subterranean peat of South Holland, and under most of the clay fens in the same district where the peat (not being continuous) is wanting. It is known all over the fens as "blue buttery clay," and is the enriching substance brought to the surface in the operation of "claying,"—giving the light black land the requisite consistence and firmness of texture, and (not being pure alumina) supplies the silica which is necessary for the growth of corn. The soil of West Fen is generally a stiff clay, with this buttery clay as a subsoil, touched by the plough; the exception to this is between New Bolingbroke and Coningsby, where about 1000 acres of the fen have a subsoil of white sand, doubtless a bed of the drift. The clay is found under the peat of East Fen, and with the peat passes under the marsh-land of Firsby, &c., underlying nearly all the long line of marshes to the Humber, and appearing on various parts of the coast at low water. It varies much in thickness: in many parts of the Great Level it is only 2 feet, more frequently 7 or 8 feet; the depth in Deeping Fen is about 10 feet, in the Witham fens about 12 feet, in West Fen from 1 to 12 or more feet, and in East Fen from 6 to 19 feet, (resting upon white marl and sand.) The strong heavy clay surface-soil of the eastern Witham fens appears to belong to this stratum.

The next bed (in an ascending order) is the peat which occupies a large portion of the fen surface. This was formed by the destruction and partial decay of a forest—oak, fir, alder, and other trees being found prostrate within it, with their roots fixed in the clay below in the attitude of growth; and is of varying thickness from a few inches to 10 feet, at a level of from 15 to 20 feet below high-water mark in the Wash.* The peat, from 1 to 2 or 3 feet thick, is found

* How the level was converted from a drowned marsh into a huge tract of woods, and how these were destroyed and changed to peat (as the universally embedded remains testify), is an enigma. If the fens were to be bared to the soapy blue clay, *i.e.* if all the uppermost beds were removed, the sea would deluge the whole plain with 3 or 5 fathoms (18 or 30 feet) of water; yet the forest grew upon this identical surface high above the flow of the tides. The dryness of the land was not owing to the embanking and draining of the marsh by the Romans, for many feet of alluvial deposit

under the alluvium of Marshland, in Norfolk, under the alluvial clay of the southern and central parts of South Holland, and occupies most part of the Bedford Level (more or less mixed with silty sediment), resting in general upon blue clay, but on gravel, sand, chalk, or hard clay near the corresponding uplands. It is found over most part of Deeping Fen, being also underneath the alluvial clay near the Welland river; in Thurlby Fen it is 10 feet in depth, and has a mixture of clayey sediment on its surface; in Bourn, Morton, &c. fens it is shallower, and gradually thins off as it runs northward. There is some extent of the black land in the southern parts of South Holland, but of no great depth. In Deeping Fen it is a light mould, generally about 12 inches thick, with clay or silt often so near the top as to be turned up by the plough, the mingled soil producing fine crops of coleseed and grain. The greatest breadth of the peat in this part of the country (across Deeping Fen and part of South Holland) is about eight miles. It stretches northward between the Car Dyke and the South Forty-foot Drain, scarcely more than 1 or 2 miles in breadth; these fens, especially east of the Forty Foot, being "skirty," *i. e.* a mixture of peat and alluvial silt and clay, forming a deep black loam. In Ewerby, Anwick, Digby, &c. fens, the peat deepens, resting upon gravel or clay, which also form much of the surface. The width here is from 3 to 5 miles. In Digby and the neighbouring fens the peat is naturally poor and hollow, producing not more than 5 quarters of light oats, or 20 bushels of very light wheat, but after mixing the clay (which lies at 4 feet depth), the land yields 30 bushels of good wheat, worth more by 8*s*. per qr. The fens of South and North Kyme, east of the Car Dyke, are better and higher land than those just adverted to (on the west of that drain); they have been long drained and cultivated, and the black soil has been much worn up by burning,

overspread a portion of the peat before the banks were erected, and the whole forest had decayed into spongy peat before the Roman roads were projected across it. It is impossible that any adequate sea-barrier could have been in existence, or if it be supposed that the *downs* or *denes* of sand had been naturally raised along the shore, it is impossible that the great rivers could have been artificially conducted over a broad country, elevated 20 to 35 feet above it, and the supposition of such a tract having been drained by pumps or wheels at so early a period of British history, and not only perfectly and deeply drained, but during an interval of time sufficient for the growth of colossal oaks and firs of an age and dimension entirely unexampled in England at the present day,—this is too preposterous to be accepted as an explanation. The only solution of the problem seems to be, that after the buttery clay had been deposited and guttered by silty creeks and rivers, an elevation of the whole country took place, and then, after a long term of years, occurred a subsidence of the land to its present level. Similar forest remains are found in many parts of the British coast, and the gradual elevation and subsequent depression of the island will account for their formation also. Of course, however, alterations in the level of the sea would be equivalent to these changes of the land. These observations are made with a view of correcting an outline of an hypothesis hazarded in the Report on the Fens (Journal, Vol. viii.), and adopted by a writer in the Edinburgh Review (No. clxxiv. p. 459).

&c., and the clay mingled with the remainder by ploughing. On the western side of the Witham the peat runs up to Lincoln, varying from 4 miles to only $\frac{1}{2}$ a mile in width; beyond that city it is soon lost in the alluvial flats on the banks of the Till, Witham, and Brant. Its depth varies from 8 inches in the southern parts to $1\frac{1}{2}$ or 2 feet over its principal extent, and 5 or 6 feet nearer Lincoln.

East Fen has a soil of black peat, generally from 2 to 3 feet deep, extending also into the East Holland parishes, and the low lands of Friskney and Wainfleet, being about 6 miles north and south by 5 miles east and west. Most of the peat, however, has now become clayey and solid. It is separated from the hills by about $1\frac{1}{2}$ miles of the Oxford or Kimmeridge clay; resting generally upon soft blue clay, though sand occurs in some parts; and beneath the clay is white marl and sand. The peat dips under the marshes of Firsby, &c., and appears on the sea coast northward of Skegness, forming a submarine forest visible only at the lowest ebbs. About 5 miles east of the Wold Hills it is found upon the surface of the plastic clay, dipping under the clay of the marshes; at Waltham the subterranean timber is 3 feet from the surface; at Skidbrook the stratum is black earth, about 4 feet from the top; at Saltfleet 13 yards from the top. At Sutton it is at the level of low-water, and rests upon the soft greasy clay; at Grimsby, and between Barrow and Barton, it is found at the same depth, and consists of peat with remains of trees resting upon similar blue clay.

The boundary of the peat is in general not well defined; but the quantity of acres in East Fen and the long western district may be estimated at more than 100,000. Where it is more than 10 or 12 inches in depth the peat has become separated into two distinct strata—a top-soil of black peat earth, or entirely decomposed vegetable matter, mixed with silt and sediment from ancient floods, and with the mineral constituents of the manures applied; while the subsoil is an infertile brown moor, sometimes a compact mass with fibres scarcely distinguishable by the eye, or else a soft spongy substance containing leaves and stems of plants. There is no need for repeating what has been already published respecting the nature and qualities of this soil; its native weakness and lightness, its power of retaining moisture, the injurious effects of its stagnant irony soakage-water upon the roots of plants, its tendency to sink down and become solid by good drainage, and its matchless productiveness when incorporated with a heavier earth—these points must be well understood by all students of this Journal.

After the peat had been formed the whole level seems to have been so low as to be almost constantly under water. The tides,

loaded with mud, sand, and animal and vegetable substances, flowed for a considerable distance inland. The salt water, by its greater specific gravity, would, as it were, undermine the freshes, the weight of which would fix a limit to the advances of the sea; and where this hindrance occurred (varying in locality according to the periodic height of the tide and volume of fresh water from the uplands), a deposit of slime would take place. Every bar of this kind raised would act as a check to the tidal waters, and thus precipitate fresh matter near it, and on that side (next the sea) from whence the sediment came. It is in this way that the sea has formed upon these flat shores, liable to freshwater inundations, a deposit which is lower and thinner as it recedes from the sea, and thus that it has covered so large a portion of the peat abovementioned with alluvium. The first bed upon the peat is from 4 to 16 or more feet in thickness near the coast, and thins off like a wedge as it proceeds inland until it altogether vanishes, and the peat comes to the surface. It is generally a mass of silty clay, without marks of lamination, traversed by innumerable small rusty veins, apparently of decayed vegetation and red sand. The Roman banks were founded upon this stratum, but since they were made the sea has deposited several feet of soil outside the banks, and also for 1 or 2 miles inland, covering the clay. This bed forms the clay of Marshland in Norfolk, and of the central parts of South Holland (called "the Fen Ends"). It is sometimes a hard "gaulty" clay, with red and blue streaks, or a hard blue clay, very stiff and difficult to manage; but it generally contains beds of silt, either under, above, or within it—like sandbeds in the new warp land. It often rests upon the buttery blue clay, and, approaching the black land, becomes of a peaty nature. Northward of Spalding it extends to Donington and Swineshead, &c., lying between the fens and the newer marsh land near the coast. In Heckington and several other fens it is found as an alluvial clay and silt, and in Holland Fen and Wildmore Fen it is a deep loamy clay, and sandy loam upon a subsoil of clay or silt. In the rich grazing district of Boston, Kirton, Wigtoft, Fosdike, &c., and the breadth of good land upon which the principal South Holland towns are built, the soil is a remarkably rich brown loam, from a few inches to 4 or 5 feet in depth, resting upon silt; and the higher grounds appear to have intercepted and retained a large proportion of the vegetable matter floating in the waters after the principal deposit had taken place. North-east of Boston it is of the same character, the portions adjoining the fen being a stiff blue clay, having higher spots of silty soil about its surface. Along the North Marshes it is a rich clayey loam, varying to a friable sandy loam or a tenacious marine clay, but generally fertile. It rests upon the peat stratum, and along many parts of this coast is 20 feet

deep; at Saltfleet 39 feet deep. Between this place and the "clays" it possesses no sand beds, and at Grimsby is a stiff blue clayey warp.* The soils, generally speaking, are very nearly alike over the whole of the marsh lands, and therefore need not be particularized.

The more recent alluvial deposit, which is chiefly on the outer side of the Roman bank, and *newer* than that bank, is generally a brown loam upon brown clay and silt. In South Holland it forms the "marsh" district, 4 or 5 miles in breadth, having a subsoil of brown clay upon a drab-coloured, dry, "sugary" silt. The upper portion of the silt lies in plates just as it was left by the tides; lower down it becomes a wet blue sand, containing sea shells. The clay is from 6 inches to 4 or 5 feet in thickness, and upon it is a coating of dark brown loam, deep, friable, and fertile. The clay, however, is frequently absent, and the soil more sandy, particularly near a sea bank (of which many yet remain, the land having been gained by successive enclosures), and on the "land" side of it. This is in consequence of there having been too large an amount of land taken in at one time, the outermost parts not being warped up sufficiently high by the sea. The tidal currents also occasioned a very unequal deposition; in some places throwing down a mass of raw sandy silt, in others bringing the finer clayey particles into a bed of rich soil. The soil usually consists principally of silica, with a much smaller proportion of alumina and iron, and an inconsiderable quantity of lime and magnesia. It is doubtless a composition of sand and sediment from the waves of the Wash, vegetable matter which grew as marsh plants on the rising mud only to be buried under fresh warp, and the animal matter suspended in the water — the siliceous and calcareous skeletons of marine and fluviatile infusoria. The marsh lands outside the old Roman embankment, between Fosdike and Boston, and Wainfleet, preserve the same character, and vary within similar limits to the above. The silt, wherever it occurs, is very porous, and contains a peculiar kind of springs, called "the Sock or Soak." Upon digging down into the sharp silt the soak oozes from the side of the hole. The depth of these springs is from 3 to 6 or more feet, depending upon the amount of rain, and the quantity of water in the neighbouring creeks or drains, and being also affected by the height of the tides.

From what has been stated it will be understood that the Wash is nothing more than a broad expanse of marsh-land in the course of formation: indeed many thousands of acres have been and are still being reclaimed from its dominion at the mouths of the large

* Since this line of marshes was deposited the sea has reversed its action, and a considerable reach of land along this coast has been eaten away. It is this encroachment that has laid bare the submarine forest.

rivers. In South Holland are no less than 59 square miles of country, or 37,760 acres, outside the Roman bank, and enclosed from the sea since the year 1660, the newest bank being about 4 miles from the first or oldest. And along the coast from Fosdike up toward Grimsby, although many places have lost by encroachments of the sea, there are probably 16,000 acres of land reclaimed during a comparatively modern period. A total quantity of 84 square miles, or 53,760 acres, have thus been stolen from the waves by embankments within the last 190 years. This is some of the highest land in the Level, being in some cases 16 or 18 feet above the general fen land; and it rises in successive steps at each of the 3 or 4 embankments which have been constructed, the latest enclosure being the highest.

Though the Lincolnshire coast is protected from excessive tidal abrasion by Spurn Point serving as a jetty to the tide-wave, the waste of the Yorkshire cliffs is very great; and this, with other material, is principally carried into the mouth of the Wash. A very small proportion of the sediment held in suspension by the flood-tide returns with the ebb, and the bay is therefore being slowly warped up by the sandy accumulations.* The sediment consists of a very fine silt, composed chiefly of particles of flint and limestone, but containing likewise alumina and animal matter. When the thickened tide-water is restrained by some simple impediment—as faggots fastened down with stakes, &c.—from returning rapidly into its channels, it will deposit from 6 inches to 2 or 3 feet of soil in the course of a summer. This deposit is not a simple sand, but a rich nutritious soil, composed of argillaceous and siliceous earths, with portions of mica, marine salt, and mucilage. The land is fit for cultivation as soon as enclosed, and produces excellent crops.

The great south-eastern alluvial district may be computed at 362,000 acres, and the marshes north of Wainfleet at 88,000 acres—and when the lands west of Lincoln are included—making a total of about 455,000 acres in one uninterrupted level (an area equal to the whole of Oxfordshire).

The Ancholme Flat, containing probably about 28,000 acres of alluvial land, has generally a peat soil resting upon clay. The northern parts of the district have a deep clayey warp of a dark

* When the immense quantity of matter thus left is considered,—the Yorkshire coast alone losing $2\frac{1}{2}$ yards annually for thirty miles between Kilnsea and Bridlington, —it is not surprising that the Wash should be nearly filled by sand banks, and its river channels so uncertain as to shift occasionally several miles in a few years. Indeed, with the exception of one broad channel running through the centre of the Wash with an average depth of 10 fathoms, the rest of the bed is a series of sands dry at low water, and shallows of one or two fathoms. The "Norfolk Estuary" and "Lincolnshire Estuary" schemes are for enclosing a large tract of these sands, and the "Victoria Level," if ever executed, will shut up 150,000 acres by barrier banks, leaving a four-miles channel down the middle of the Wash.

colour, a mixture of clay, silt, and vegetable matter. This has evidently been deposited from the muddy waters of the Humber, which, previous to the erection of the banks, must have inundated the level with from 4 to 9 or more feet of water. At Ferriby Sluice the alluvial silt and clay is more than 25 feet in depth; the beds upon which the alluvium rests have not been examined. The clay underlies the whole surface of the level, and was doubtless deposited by the Humber waters and the streams from the hills. Under the hills by Horkstow, Saxby, &c., is a line of soft peat, forming wet and rushy grass land. In Worlaby and other adjoining "carrs" the soil is peaty with a clay subsoil, the clay being often near enough to be brought up by deep ploughing. In Roxby and Appleby carrs, on the west side of the river Ancholme, there are 3 or 4 inches of peat upon blue clay which are mingled with excellent effect. This district stretches as far southward of Brigg as that town is from the Humber, and in the southern part the soil is a spongy peat, containing black wood or subterranean timber, and the clay is generally too deep to be touched by the plough. There is much sediment mixed with the peat, and the substratum of clay is evidently a warped soil.

On a large sand-bank in the Humber, opposite Ferriby, called "the Old Warp," about 100 acres have been embanked. The ebb tide scours away the soil from the Yorkshire side of this island (about 4 miles long and 1 mile broad), and an addition is being continually made to the Lincoln side: the embankment has been made on that portion which is not liable to "turn over."

At Wintringham the marsh becomes very narrow; it is an excellent warp soil, 6 feet in depth.

Along the east bank of the Trent is a belt of alluvial soil a few hundred yards in width, deposited by the ancient overflowings of the tide—a rich earth capable of growing any crop. The flat land extending between this and the foot of the Red Sandstone and Lias Hill was a tract of peat moor, worth nothing but to cut fuel from, but is now (with but few exceptions) covered with from 18 inches to 3 feet of the richest artificial warp. Probably the alluvium and remaining peat may have an extent of 8000 or 9000 acres.

In the Isle of Axholme are about 15,000 acres of warp land, partly a natural deposit from the Trent, and partly obtained from floodings of the tides upon the low sand and peat. This soil is remarkably rich, and the chief part of it is capable of growing every description of garden and vegetable produce. The warp upon the white or grey sand is usually the best, for it has then a natural subsoil drainage. The same tidal action has been at work here which deposited the alluvium of the south-eastern district highest next the sea, the land next the Trent becoming lower as it leaves the river. Near the river, at Althorpe, &c., the blue

clayey warp is several feet in depth, and underneath it are found the remains of trees lying upon peat moor. Below the moor is a soft blue "pipy" clay, *i. e.*, containing pipes of red rusty matter, probably the decaying roots, &c., of marsh plants. Two or three miles west of this point of the river, before the warping works were commenced, this natural warp was about 18 inches deep, with moor beneath it, containing oak, fir, and yew trees: further inland the peat is at the surface. The peat, when separate from the sand, occupies only a small portion of the low lands of the isle, viz., along the western side and in the neighbourhood of Wroot, &c. It is generally a dark, boggy peat, 3, 4, 5, or more feet in depth; but in Yorkshire (over the border of this county) it is widely developed, and forms the peat moss of 10,000 acres, called "Thorne Waste,"—10, 12, and even 18 feet in depth, resting upon sand. An overthrown forest appears to have been the origin of this spongy moor; but as the tide can now flow probably 3, 4, or 5 feet above its surface, the ground upon which the trees grew is 15, 20, or more feet beneath the present level of the sea at high water. The alluvial beds east of the Trent exhibit a similar structure: and the chief part of the subterranean forests grew upon the sand. The deposits are of the same nature, and have a similar order of succession, to those of the fens; and it may therefore be inferred that the same causes produced both, viz., an elevation of the land and subsequent depression, or else corresponding alterations in the level of the ocean.* It is hoped that the facts (or rather the summary of a profusion of facts) which have now been stated respecting the strata of alluvial deposits in the low lands of this county, and the great level of the fens, will be of assistance to those writers who base their theories of the origin of the fens upon a few facts recorded by Dugdale and other historians, or else generalise from isolated circumstances observed by themselves.

The approximate amount of alluvial lands in Lincolnshire may be recapitulated as follows:—

* De La Pryme (in 1700) says, that "round about by the skirts of the Lincolnshire Woulds unto Gainsburgh, &c., &c., are found infinite millions of the roots and bodies of trees of all bignesses;" and as the trees are mostly burned down or felled, and Roman remains have been here found, he concludes that the destruction of these forests was a work of that people. However, a change of the relative sea and land levels must have occurred, and before the Ouse and Trent waters pursued their present course; and in the south-eastern Fens the Roman banks testify that no such alteration has happened since their erection. The *Aborigines* may have set fire to these woods during a gale (the trees principally lying in one particular direction), and may have chopped down much of the timber. Canoes and other British antiquities have been found here and in the peat and sand east of the river Trent. The various Roman and other remains may have sunk into the bog land after the destruction of the forests. Both Roman and British antiquities, and remains of deer, beavers, wild boars, &c., are also found in the fens; but archæology must not confute geology, and these fragmentary evidences cannot prove the occurrence of a physical impossibility.

	Acres.
Great southern and eastern tract . .	455,000
Ancholme Level	28,000
Isle of Axholme, and lands east of the Trent	29,000
	512,000

In the absence of any geological map or section of this county, considerable pains have been taken to construct such as may convey a tolerably accurate knowledge of the different strata. The accompanying sections require no explanation.

2. *The Drainage of the County in a General View, and the Improvements which may yet be effected therein, especially by forming Natural instead of Artificial Drainage.*

The peculiar difficulties attached to the drainage of this county appear from the following facts :—The whole of the Alluvial lands, together with the low sands, &c., in the Isle of Axholme, and on the east side of the river Trent, a total extent of about 522,000 acres (nearly equal in area to the whole of Cambridgeshire, and larger than several of the other English counties), are lower than the sea; the level varying from 4 to 16 feet below high-water mark in the German Ocean; and over most of these flats (all the south-eastern district, and likewise the Isle of Axholme), the most elevated grounds are those nearest to the shore, the surface gradually declining to its lowest point near the uplands. Still further, the lowest and most inland parts generally consist of a spongy peat, which has a natural tendency to hold water and continue in a swampy state. The great district extending between Lincoln, Wainfleet, Deeping, and the Nene estuary, is of this conformation. It has an area of about 362,000 acres, and is 24 miles in breadth at its broadest part (from near Bourn to the sea-coast in Long Sutton Marsh), and 12 miles across its narrowest part (from the high lands near Helpringham, &c., to Fosdike Wash). The peat soil reaches for 30 miles under the slope of the western hills (the general length of this broad district, north and south, being 35 miles), and with the similar land in East Fen covers upwards of 100,000 acres. But the lowness of the surface, the absence of any slope towards the sea, the actual fall away from the points of discharge, and the boggy nature of a great portion of the country, are not the only obstacles to be overcome. The great bay or wash, which forms the sole receptacle for the drainage waters, is so shallow, and daily receiving such accessions of sand and mud, that it is impossible for the waters of this low plain (wanting an impulse to carry them forward) to scour an open passage through the bars with which the river-mouths are choked. The only power competent to accomplish this object

is the impetus of the upland rivers, which, descending from a higher level in streams of considerable force and volume, can drive out the impediments from their beds, and maintain a seaward channel through the shifting deposits of the Wash. But this power has to be made available by works of engineering. Naturally these rivers pour down the accumulated floods from this and other counties upon the fens at their lowest points, when they at once lose their velocity and momentum, being in reality discharged many miles before they reach the sea; and thus, instead of opening an outfall for the fen waters, assist more disastrously to deluge the level. To prevent this, the high land rivers are caught at the point of their fall, and conducted over the land as in raised aqueducts, between high and strong embankments. Nevertheless the fall thus secured is very trifling, only from 3 to 4 inches per mile. The high-country water being thus disposed of, and an outfall thereby provided for the low land water, the desiccation of the level is effected by erecting barrier-banks to fence out the tides, and then providing adequate means for drawing off the water. The general drainage of uplands is accomplished spontaneously by their natural slopes and valleys, without the contrivance and labour of man; but these marsh grounds must be embanked, and the issue of the land-waters regulated by sluice-doors in the banks, emitting the freshes when the tide sinks beneath the level of the inside water, and preventing the ingress of the sea when risen above a certain level. Over a large portion also, the drain-water has to be mechanically lifted into the necessarily high-riding main-drains and rivers. About one-fourth of the whole surface of 362,000 acres is at present artificially drained.

The distribution of the drainage connected with this wide lowland is as follows:—The river Witham (nearly the whole course of which is within the county), originating among the limestone-hills, not far from South Witham, flows through a narrow valley to Grantham and Marston, where it leaves the foot of the cliff, and enters upon the broad lias valley, receiving many becks and rivulets as it winds towards Lincoln. About 5 miles before reaching that city it is joined by the river Brant, which skirts the oolite ridge from Hough. These waters, from about 130,000 acres, are joined at Lincoln by the water of the river Till, &c., from about 46,000 acres; and the river has then to flow at least 36 miles across the fens, with only a slight fall. Near Horsley Deeps it receives the Langworth river from the Heath and the broad drift district; and at Dogdike, the river Bain, about 28 miles from its source among the chalk hills—this being the drainage of 162,000 acres. Between Lincoln and the confluence of the Sleaford navigation and Witham, the river passes

between embanked fens, and is augmented by numerous high-land streams, "delphs and skerths," on each side; those on the west flowing between lofty banks, and entering the river at right angles to its course. It is thus fed by the waters from 94,000 acres more. The floods from about 12,000 acres, falling by numerous becks down the declivities above Wildmore, West and East Fens, enter the Witham at and below Boston. Many streams pour down upon the peat fens from the hills south of Sleaford, and are carried off by the South Forty-feet Drain. This large main drain runs parallel with the high lands, at almost 2 or 3 miles distance from the Glen river bank to near Swineshead, north of which place it turns directly eastward to Boston, receiving on its way the drainage of Holland Fen. About 108,000 acres of high lands drain into this canal. The total quantity of high lands discharging their drain-water by the Witham Haven is therefore about 550,000 acres; and there are also about 148,000 acres of low lands discharging by the same outfall.

The river Welland, from the midland counties, enters Lincolnshire at Stamford, and traverses a low plain to Deeping and the neighbourhood of Crowland, when it turns northward to Spalding. Receiving the river Glen and several fen-drains, a few miles below this town it empties into the sea by Fosdike Wash. The Welland flows 24 miles over the fen district, from Deeping to its outfall.

The river Glen has two sources between Grantham and Folkingham, which, running through parallel valleys in the oolite hills, unite and enter upon the fens near Baston. It brings down the floods from a district of about 54,000 acres, and is carried 19 miles across the flat country, between embankments. In addition to the upland waters from Rutland and Northamptonshire, &c., about 54,000 acres of high ground in this county, therefore, and also about 64,000 acres of fen and marsh, drain by the Welland estuary.

The Welland and Witham outfalls are, in fact, only one; for the two channels unite among the Wash sands at a point not more than 2 miles distant from the shore. Thus, out of the whole district of 362,000 acres (alluvial land), about 212,000 acres evacuate at one outfall. And besides this, all the waters which descend upon this level from the uplands, viz., the drainage of about 604,000 acres (together with the Welland floods from other counties) are discharged by these rivers; so that about 816,000 acres, or very nearly half the county, empty their downfall water at the same point of the Wash. So sluggish are the fen streams that it is only by such a combination of weight and current that the ebb-tide and freshes can grind out the bars of

silt deposited by every flood-tide; and even then considerable difficulty is experienced in maintaining clear channels for the rivers to their junction. The Witham has been strengthened below Boston, and the Welland has been artificially compelled to scour itself a direct channel through the sand-banks of the estuary, to secure a *minimum* of obstruction to the flow of the back-water, and freedom from angles and bends which favour the deposition of sediment.

The whole sea-coast of Lincolnshire, a line of at least 112 miles from the mouth of the Nene to that of the Trent, consists of marsh lands lower than the tides at high water, and barrier banks extend (with some trifling exceptions) along the whole of this length. All these must be kept in constant repair; and, besides these defences, there are at least 70 miles of bank on the river Trent (viz. 35 miles on each side) daily abraded by the swift and impetuous tides from the Humber, and the long banks of the various rivers already noticed, requiring continual labour and attention. Along the greater part of the shore, two, three, and sometimes four ranges of embankment are found at a considerable distance apart from each other, being the boundaries of successive enclosures from the sea. The lands included between these ancient barriers are on a higher level than those first enclosed, and the most recently reclaimed are more elevated than the last before them, so that the surface rises a step at each embankment as it approaches the sea. Consequently, the fen waters, having to pass through the higher marsh grounds to their outfall, require large main drains, but the lands next the outer sea-bank drain by means of small sluices in the embankment, being high enough to drain over the flats and shoals without a deep channel scoured through them. Between the Trent mouth and the Nene outfall are more than 60 of these "gouts"* or outlets, without including the larger sluices upon the main drains and rivers. These waters, and indeed all the water discharged by the Fen rivers with or without sluices, have to be emitted during those hours of each day in which the tide is below a certain level—the flow outwards being impeded by the pressure of the higher salt water for the remaining period.

The drainage of *South Holland*, the district east of the river Welland, is divided between several distinct outfalls and respective works of drainage. The higher or "old" lands, on which the principal towns are situated, together with a portion of the clay fens south of them and the whole of the marshes north and east, drain by small outlets and private sewers, as mentioned above; the public sewers being under the care of commissioners

* Pronounced "*gotes.*"

who are appointed to repair the old drains, and are empowered to tax all lands benefited, or supposed to be benefited, by their works, and fine for non-payment, without being responsible to the tax-payers for the use made of their money. The drainage is in general good, but many of the marsh farms might be greatly improved in this respect. Many sluices need to be lowered, the creeks narrowed, and the minor drains deepened. Throughout most of the marshes there is not sufficient attention paid to the depth and capacity of tunnels and of division ditches. The fields are regularly surface-gripped as soon as the wheat is sown, and considerable difficulty is experienced, after a great fall of rain, in keeping the water off the surface; and the water in the dikes is frequently within two feet of the top of the land for months together. Perhaps this inefficient state of the drainage may be unavoidable where the only outlet is by feeble currents through the muddy sands; but in those districts which drain by sluices into the good outfall of the Nene it must be a hurtful negligence which permits an inadequate system of drainage when a *perfect* natural fall is offering every facility for the egress of the water. An example occurs in the lands adjoining "Lutton Leam," a channel conducting the drain water from lower grounds (more inland) to the Nene, which also forms the outfall for the former lands. These higher grounds next the river are not allowed to drain into the Leam (to the detriment of the low lands); but the water in the Leam is several feet lower than their water, and as all of it empties into the same outfall, it is evident that the water of these lands might be kept quite as low as that in the Leam, and thus a fall of several feet be gained.

On the land that has been underdrained—only a small proportion of the whole—surface-grips are rendered unnecessary; but, from the want of a good outfall and the sandy nature of the bottom soil, the drains are much too shallow, seldom laid more than 24 or 30 inches from the surface. Though the marshes are wet in winter, there is often a scarcity of water in summer, so that the general practice is to let in water through the sea-banks in a dry season. The dikes are used for fences as well as drains, and such is the porous nature of the earth that the water oozes away in summer, leaving the ditches empty, the fields being thus destitute of fences for the stock. The salt water is then admitted, but it is a question whether this convenience is not too dearly bought, as the tide-water brings in a great quantity of earthy matter and silts up the drains. Throughout all the marshes and many of the fens are found those subterranean currents called the *soak* or *sock,* the depth of which from the surface depends upon the fall of rain, the height of the tides, and the quantity of water in the ditches. Upon this soak depends in a great measure the quantity of water

in the wells and ponds, of which latter there is one in each field. The sea and river water is therefore admitted for the double purpose of fencing and watering the stock; but it has been suggested that by planting quicks (and many have already been set), by deepening the ditches, and puddling the ponds (if needful) with clay, a better drainage might be obtained that would amply repay all the expense by the improved crops and pastures. Great loss is now experienced by the graziers, in consequence of the injury done to their sheep and cattle by the saline qualities of the herbage and the brack water in the ditches—the total exclusion of salt water, and a deep subsoil drainage, are the remedies for this evil.

About 32,000 acres of the lower and southern portions of this great district (including the lands which drain by an ancient sewer —called the "Lord's Drain"—into the Welland) form what is called the "South Holland Drainage," the great outfall of which is the river Nene. The drainage waters from this tract had formerly to pass northward through the higher grounds, in consequence of which it was flooded three-fourths of the year. Raven's Bank and others yet remain that were anciently made to defend the marsh towns from the fen waters, and the grass fields contain many parallel trenches evidently excavated as reservoirs for the floods and the earth raised up as a refuge for the cattle. As the stock used to forage in the wet grounds, and have their lair on the higher spots, the "hills" in such fields are now found to be the richest pasture. The main drains run eastward from Peakhill near the Welland bank to the sluice on the river Nene, near Sutton Bridge, intersecting almost at right angles all the ancient drains and sewers. For many years after the formation of the drains, the country remained in a deplorably wet state, though saddled by an enormous drainage-tax; and it was not until the great works of the Nene outfall in 1829 lowered the head of water about 6 feet at the sill of the sluice, that the low lands were recovered from their unprofitable condition. The lands in South Holland in great wets are not so well drained as they ought to be, and therefore a new sluice is proposed to be erected, having a sill laid 5 feet lower than the present one.*

There is a tract of land immediately north of the South Holland Drain, in Gedney and other parishes, which is badly drained, the water having to traverse a flat and angular course of about 8 miles to its outlet by Lutton Leam. The district of Great and Little Portsand (commonly called "Postland")—7450 acres near Crowland—is drained under the authority of the North-Level Commissioners, the water being conducted by the South

* 1851. This has been already commenced.

Eau* and the North Level Main Drain to the Nene at Gunthorpe sluice. These new works, opened in 1834, in connexion with the Nene outfall improvement, gave this district a good natural drainage; but further improvements are contemplated. The present wooden bridge over the Nene (at Sutton Bridge, below the South Holland sluice) has a dam of stones at its foundation, which so impedes the current as to create a fall of from 2 to 3 feet. A new bridge is now in course of construction that will obviate this impediment, and so give to South Holland, Portsand, and also to far more important districts in the neighbouring counties, the benefit of this additional fall.†

The first drainage of *Deeping Fen*—about 25,000 acres of the lowest Lincolnshire fens, lying between Spalding and Market Deeping, bounded by the rivers Welland and Glen—was in the reign of Charles II. This was done by raising the water by windmills into the main drains; the river Welland having been more anciently embanked, and several drains and sluices constructed at the attempted drainage in the time of Charles I. The land was thus freed from inundation during a part of the year, and continued until 1801 a region of open common, producing "exceeding store of grass and hay." In 1801 the Inclosure Act was procured, and the North and South Drove drains were cut, to take the water from more than 40 mills. The Fen was generally under water in the winter months; but in a tolerably dry spring, with the assistance of the wind-engines (which were on almost every farm), the farmers managed to sow oats by the end of April, the greater part not being sown before the middle or latter end of May. In 1824-5 the present steam-engines (of 80 and 60-horse power) were erected at Pode Hole, near Spalding, and the drains were deepened, the expense amounting to 5*s.* per acre for 4 years and from 2*s.* to 4*s.* per acre for years afterwards. The drains were insufficient, however, for carrying the drain-water to the engines, and still the windmills were kept up. In 1831, &c., the old drains were deepened 3 feet, and a new one excavated on the west side of the district; and not one windmill has been used since this improvement. The outfall for the engines is the Vernatts Drain, which unites with the Welland a few miles below Spalding. It is probable that the outfall improvements of this river, when the channel has been straightened quite to deep water in the Wash, will give a natural drainage to Deeping Fen. The internal drains are of the best description, and kept remarkably clear from weeds and "cot." About 4000 acres lying farthest from the engines are not well drained, the

* Pronounced "Ee," "O," and "Or," in different localities.

† 1851. This is now finished; and the fall at low water is, we believe, reduced to less than 6 inches.

water in the ditches during the winter being seldom lower than 15 inches from the surface.* This is considered a good drainage by many who were accustomed to the wretched system of wind-drainage, their mills having been frequently unable to effect their duty until the water had remained so long upon the soil as to dissolve most of the nutritious salts and manures which it contained. Nothing is more certain than that water stagnating near the surface of the fen lands for any considerable time greatly injures the roots of growing wheat, and likewise destroys clover and all those valuable grasses which strike their roots deep in the ground. Besides this, when put in motion by wind or steam-engines, it washes out of the soil and carries away with it the soluble fertilising particles, thus occasioning a lasting injury to the productive powers of the land. Hence there can be no doubt that many lands, usually regarded as well drained, do in reality suffer very much from the causes here stated, even when water is seldom or perhaps never seen level with their surface. A testimony to the truth of this remark may be drawn from the dark blood-coloured water which is thrown out by mills, whereas in those parts where the drainage is by the natural descent to sea, and is tolerably rapid, the water in the drains is colourless and transparent. The truth is, that all the water which cannot be retained by the soil, evaporated by the air, or absorbed by vegetation, ought to be drawn off the soil without being suffered to stagnate; it has then no time to dissolve the soluble matters mixed with the soil, but, on the contrary, by its slow and uniform filtration through the earth, communicates and mixes the various substances in that equal manner which is most conducive to fertility.† To accomplish this a perfect subsoil drainage is required, but first of all the water-level must be kept 2½ or 3 feet (at the least) below the surface of the land, and the outlet always kept open in winter, so that every shower of rain that falls in excess on the soil begins, without a moment's delay, to pass gradually away. In the North Level (Cambridgeshire) since the natural drainage was introduced there is a marked increase of fertility of parts which were previously held to be well drained; and, doubtless, a similar result would accompany the better drainage of the lower lands in Deeping Fen and other districts in Lincolnshire. It may yet be long before Deeping Fen obtains a natural outfall, but an advantage might certainly be gained by lowering the wheels of the engines, seeing that the "head" of

* It must be borne in mind that the fen land, with the exception of those parts raised by the earth cast out of drains, &c., seldom varies 6 inches or a foot from one uniform level.

† For further remarks upon this point see "*Considerations on the North Level,*" a work by the well-known *Tycho Wing, Esq.*

water outside has already been considerably lessened by the amendment of the Welland channel. By reason of drainage the fen has subsided at least 2 feet, and thus the lowering of the wheels is both practicable and necessary. By this alteration the drainage-water might be scooped out at any rate one foot lower than at present, which would be of great benefit to the lower portion already noticed.

Great quantities of water are let in from the upland rivers during the summer, to water the fen. This practice hinders the work of drainage, by increasing the amount of work to be performed by the engines, and by diminishing the quantity of backwater which keeps the outfall open during the dry season. The peat land becomes so dry, and subject to be blown by high winds, that this watering is affirmed to be necessary; the consolidation of the soil, however, by draining and claying will probably obviate this necessity, and the upland waters will at a future time perhaps be employed for irrigating instead of injuring the fen. It is quite *possible* to dispense with the practice on some of the lower lands, for on one farm the water has been kept by a private steam-engine two feet lower than that of the surrounding neighbourhood, and not a single pint of water was "taken in" from the drains; the effect being the production of more equable crops of grain. Very few farmers have set down private wheels; but where such is the case an indisputable benefit is sure to be felt. That the powerful Pode-Hole engines are capable of thoroughly drying the Fen, provided the high land water were excluded from the ditches, is demonstrated by experiments made with a Dalton gauge: the engines removing exactly the excess of downfall water over that evaporated.*

* The average fall of rain during the six years 1838-43 upon Deeping Fen was 27·50 inches, or 69,632,393 tons of water on the whole 25,000 acres. The average weight of water lifted by the engine in those years was 24,704,828 tons. This is equivalent to 35·4 per cent. of the quantity of rain fallen; but much of it consisted of the water admitted from the rivers in summer, and the quantity therefore remaining to be evaporated must be about 75 or 80 per cent. The average downfall throughout England within the same period was 26·8 inches, and the evaporation 57·4 per cent.; by comparing which facts it appears that this fen was superfluously charged with water. That the engines are of sufficient strength and magnitude to remove the necessary proportion of downfall water, is apparent from the following fact:—In 1848 the fall of rain amounted to the great quantity of 34·3 inches, or 86,850,585 tons upon the surface of the fen; the quantity lifted by the engine was 42,695,663 tons, equal to 49·1 per cent. If then, the upland waters were never admitted, the engines are capable of leaving only 50·9 per cent. of the heaviest downfall to be removed by evaporation. As the Pode-Hole engines were probably the first ever erected in the fens, a few particulars regarding them are worthy of notice. There are two engines under one roof, the one of 80, the other of 60 horse power. The wheel of the former is 28 feet in diameter, and the float-boards are 5 feet wide. It was intended to "dip" 5 feet, but, owing to the subsidence of the land, there is seldom a dip of more than 2 feet 9 inches. The water is lifted on an average 7 feet, and at the above dip lifts 160 tons per minute. The other engine has a wheel of 30 feet diameter and 5 feet in width. This dips 14 inches lower than the 80-horse wheel, so that, when the latter has a dip of 2 feet 9 inches, there is a

For several miles along the river Welland, south of Spalding, is a tract of meadow unembanked from the overflow of the stream. This is from a quarter to three-quarters of a mile wide, containing about 1500 acres, and is named *Cowbit Wash:* it is in some places constantly under water, and the whole area is frequently flooded with water several feet in depth. There are three great Washes in the Great Level of the Fens (this being the smallest), which formed a prominent feature in the schemes of Sir Cornelius Vermuyden, who was employed as engineer by a company of drainers during the Commonwealth. The upland rivers were supposed to bring down a sufficient amount of water to preserve their own outfalls, especially when aided by the fen waters; but there appeared to be too much in winter and too little in summer, the outfalls being too contracted for the freshes during the one season, and choked with tidal deposits in the other. The "wash," or reservoir, being connected therefore with a river, fulfilled the same office as the air-vessel of a force-pump—it received the sudden flushes into an expanded area, and supplied a constant current towards the sea, thus regulating and equalising the flow. This was ingenious; but experience has shown that the grand defect was in the condition of the estuaries rather than the irregularity of the current, and that nothing but the aggregation of force possessed by swollen winter floods can erode a durable channel through the growing impediments of sand.

All that is requisite for the draining of Cowbit Wash is an alteration in the river channel through the town of Spalding; either a new channel might be cut, or the present course enlarged in dimensions. The river has so long been in a defective state above its union with the Glen that it was very anciently abandoned as an outlet for draining the fens, and the lowland water was discharged first by the "Cowbit tunnel," under the river, and then by the Vernatts drain, which joins it at a point nearer the outfall; and there is small hope at present of its ever being renovated in direction and capacity for the improvement of a comparatively small extent of land.

North of the Glen river is a triangular district of land called *Thurlby Fen,* bounded on the north by Bourn Eau, or Navigation (which joins the Glen at Tounge End), and on the west by the Roman Car-dyke.* It contains only 2000 acres; but, being an

dip of 3 feet 11 inches on the former, with which it lifts 140 tons per minute. The total weight raised is therefore 300 tons per minute when both engines are at work. The average annual consumption of coal is 1200 tons; but in 1848, 1700 tons were used. An idea of the shape of a scoop-wheel may be formed from the drawing at the end of this section.

* The Car Dyke is the remaining vestige of a great Roman canal which skirted the high lands from Peterborough up to the Foss Dyke, another Roman canal, beyond Lincoln. It divides the fen lands from the high grounds along its whole course, except

independent drainage unconnected with any of the larger districts, it deserves a notice here. Many years ago 1000 acres of it (a very large proportion) were allotted to an "Undertaker," or contractor, for draining the whole, which was done by cutting several drains and making a culvert underneath the Glen river into Deeping Fen. Though much lower than the water in the embanked river and Eau, the surface is more elevated than the level of Deeping Fen, having a natural drainage into the same main drain which receives the water from the steam-engines of the latter district. The drain-water is carried from the culvert to Pode-Hole by the Counter-drain, which runs parallel with the Glen, receiving its leakage, and draining the higher land between it and the river bank, besides other lands further west. The drainage of this fen is not so complete as it should be; and as the soil is a very deep peat, good drainage will necessarily occasion a considerable subsidence of the surface, so that a fall of several feet will yet be required before an adequate natural drainage is obtained. At present, the Pode-Hole engines, when at work, raise the water in the Vernatts drain, so that the counter-drain sluice must be shut to prevent the water from reverting into the fen; a great advantage will therefore be felt when the head of water in the former drain is further lowered by means of the Welland outfall works. Several hundred acres of the district under consideration, named "Thurlby Pastures," are "fed" by water from the Glen in the summer: these are the lower grounds, and as breaches of the river bank are not infrequent, it may be readily imagined that the soil is not generally in a sufficiently dry state.

Immediately west of Pode-Hole, lying between the northern boundary of Deeping Fen and the Glen river, is a district of about 1700 acres, called *Pinchbeck South Fen,* which drains also by the Vernatts drain. The water is raised by a steam-engine of 20-horse power, built in 1830, at an expense of about 3000*l.*; it is situated a little below the Deeping Fen engines.

Extending from this district to the reservoir (where the Vernatts drain and the Glen unite with the Welland) on the south-east side of the Glen, is a narrow tract in the parishes of *Spalding and Pinchbeck,* comprising between 4000 and 5000 acres. Although so near to a great outfall the land was formerly very wet, but an Act being obtained in 1832, a steam-engine of 20-horse power was erected, and now lifts the water into the Glen from the Blue Gout drain, which runs through the district. Both the above districts must of course derive considerable benefit

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for about six miles between Billinghay and Heckington, when it has fens on each side. It is still used in one place for the purpose of navigation, and part of it employed as a drain; but throughout most of its length it is found as a small ditch and bank, though anciently 60 feet in breadth.

from the Welland outfall works; and if they should fail in obtaining a natural fall, still the lowering of the head of water will greatly lessen the expenses of working the engines.

The *Black-Sluice Drainage* comprises all the lands which empty their drain water by means of the South Forty-foot Drain into the Witham Haven at Boston; extending 20 miles northward from Bourn Eau to Kyme Eau and the river Witham, bounded on the west by the high lands, on the east by the Old Hammond Beck, and including Holland Fen, which stretches between the Witham and Hammond Beck nearly up to Boston. There are about 65,000 acres of taxable lands emptying themselves into the South Forty-foot, besides many thousand acres which drain by it without paying any tax. Hammond Beck is a very ancient sewer, running nearly parallel with the South Forty-foot, and discharging at the same point of the Witham; and, in conjunction with Risgate Eau, near Gosberton, and numerous "lodes" flowing in an eastern direction, conducted the upland and fen waters to the Witham and Bicker Haven; the northern portions of the district drained by Heckington Eau and Gill Syke into the Witham at Langrick Sluice, and by the Holland Dyke and "the Skerth" into Hammond Beck. In 1638 a drain was cut by the Earl of Linsey, following about the same course as the present South Forty-foot, and these fens were partially drained; but no permanent improvement took place in the general drainage until after the formation of the new Witham channel. About the year 1720 the North Forty-foot Drain was excavated in Holland Fen, and vast quantities of water were discharged into the Witham, just above Boston, which used to enter through the Langrick Sluice higher up the river; in consequence of this and similar diversions the river became landed up by the sediment of the tides. The bed of the river was so completely obstructed that there seemed to be no remedy but the cutting of a new channel and erecting a sluice at Boston, and accordingly an Act for these purposes was procured in 1762. The Grand Sluice* was opened in 1766; and the contemporary works comprised the execution of a new cut "from the Grand Sluice to Anthony's Gowt, from thence to Langrick Ferry, and from thence to Chapel Hill," a total length of about 10 miles, embanked on both sides. This new canal straightened as well as opened the channel of the river, which had previously pursued a meandering course of more than fourteen bends, of course highly prejudicial to the drainage. From Chapel Hill to Lincoln the Commissioners were to

* This sluice has four arches, each about 24 feet wide, thus giving a clear waterway of 96 feet: three of these are appropriated to the drainage, the fourth has a lock attached to it for the convenience of navigation—but it is also used for drainage when necessary.

"cleanse out, widen, deepen, and embank the river," which labour was completed in 1788; the sum of 60,450*l.* having been expended in carrying the provisions of the Act into execution. This expense was levied by rates and taxes on the lands draining by the river, and by tolls and duties on the navigation. The Witham Act made provision for the drainage of 100,000 acres, which it divided into six "districts;" but several of the works contemplated by the Act were never executed. The fens between Holland Fen and Helpringham (formerly the Sixth district) found themselves under the necessity of finding another outfall than the Syke and the Langrick Gout; and an Act was therefore obtained in 1765, when the South Forty-foot was cut, the "Black Sluice" erected at its outfall, and several old drains improved. The Forty-foot is upwards of 21 miles in length, intersecting at right angles all the eaus and lodes that descend from the great breadth of high land on the west; and as the fens through which it passes are very low, it may be easily conceived that the drainage of the southern parts is very defective. The district most remote from the outfall is Bourn Fen, containing (with Dyke Fen) about 4600 acres. The land was formerly extremely wet, and occasionally flooded by breaches of the Glen bank, which generally ruined the crops on the low lands whenever they occurred. The head of water in the Forty-foot being too high in rainy seasons for the drainage of this fen, recourse was had to the horse-wheel to raise the drain water. In 1841, after a protracted struggle with the Black Sluice Commissioners, an Act of Parliament was obtained "for the better drainage of Bourn and Dyke fens;" and a steam-engine of 30-horse power was at once erected, to lift the water into the Forty-foot. The drainage has been very greatly improved, but more important benefits are approaching. In 1846 an Act was passed for improving the Black Sluice drainage, and this fen, after having established a steam drainage at an immense outlay, will shortly discharge its waters by their natural descent to the sea. The engine, however, may still be of service in maintaining a low level of water in the ditches, especially as the light peat soil is found to sink so rapidly when well drained and cultivated. Northward of this fen are Morton, Haconby, Dunsby, &c. fens, up to Hale Fen (being the lowgrounds of fourteen different towns on the hills), which drain directly into the South Forty-foot; and on the east side of the drain are Pinchbeck North Fen, Gosberton, Surfleet, &c. fens, up to Bicker Fen and Swineshead (being the low grounds of eight Holland towns), emptying into the same canal. There are many windmills in these districts to assist the drainage of the lower lands, and consequently much of their surface is liable to be inundated during wet seasons, when (as usually happens) there is

an accompanying lull of the winds. But a considerable propor tion drains naturally, the mills being chiefly on the west side of the Forty-foot; the water during winter, however, is much too near the surface for good subsoil drainage. The rivulets that flow down upon the western fens are embanked over the flat land, and delivered into the drain, whilst the mill-drains and ditches are thus preserved from the upland water. The fens of Howell and Ewerby, west of the Car Dyke (into which their water is thrown by mills), and the fens of South Kyme and Heckington, with other minor districts between the Car Dyke and Holland Fen, exhibit on the map a network of drains, dykes, eaus, and skerths, crossing each other in apparent confusion: in fact, there are two distinct systems of drainage, one pointing eastward to the Witham, the other southward to the Forty-foot; and since the former outlet has been stopped, the currents of the first set of drains have been turned round and constrained to take a new direction towards the new outfall. The consequence of these sharp angles, independently of the crookedness of the drains themselves, is a bad drainage by means of wind-engines. The head of water, however, both in these and the more southern districts, is not high, the water being lifted only from 1 to 4 feet. Notwithstanding, all the lands, reaching as far as Little Hale Fen, are obliged to pay an acre-tax to the Witham Commissioners.

Holland Fen, about 22,000 acres, lying between the fens just mentioned and Boston, and termed the Second District by the Witham Act, has an excellent natural drainage by means of the North Forty-foot, Clay Dyke, Hammond Beck, and several smaller drains, into the South Forty-foot. The inclosure and drainage of this tract was under an Act passed in 1767; and Heckington and Helpringham, &c., fens were inclosed and drained about the same time. Before this took place, the whole country was frequently under water for several weeks together between Boston and the hills, the inhabitants traversing the flood by means of boats. At the present day it is not enough that the drains keep the water always below the surface of the land; but considerable exertions have been made to provide all the Black-Sluice districts with a complete natural drainage, and give to those that already possess this advantage a further facility for carrying out all the scientific improvements in husbandry which depend upon a perfect deep-draining of the soil. It is now more widely understood, and believed that an excess of moisture in the land is deleterious to the growth of plants, both by hindering the preparation of food for the roots and by preventing the healthy action of the leaves, in consequence of the dampness of the atmosphere; and that the warmth of both soil and climate is materially increased by efficient drainage. So great is the amount

of heat stolen from the soil in the process of evaporation that it has been estimated every gallon of water prevented from evaporating by being drained away adds as much to the temperature of the soil as six gallons of boiling water poured into it. Evaporation removes from this district, on an average throughout the year, about 45 gallons per acre in an hour, which, however, is reduced to 18 gallons in the wet months; and if, therefore, water is allowed to lie on a fen three days longer than it otherwise would do, there are 1296 gallons more per acre evaporated than there would otherwise be, and an amount of heat lost from the soil equal to that contained in 144 hogsheads of boiling water. The extent of land in the Black-Sluice district suffering under the above disadvantages is probably 30,000 acres, a great part of it being drained by mills, which seriously delay the discharge of the water. In order, therefore, to send the waters away rapidly—thus removing a greater quantity, and leaving less time for evaporation—extensive improvements are now in progress; including the amendment of the Old Hammond Beck, the enlarging of the section of the South Forty-foot, and deepening it 7 feet, and the construction of a new sluice at the outfall. The sluice is already completed, having a clear water-way much wider than that of the former one, and a sill 5 feet lower; and the Forty-foot is at this time (1850) perfected as far inland as Heckington Fen.*

Between South Kyme and Billinghay, extending between Kyme Eau and Billinghay Dales east, and the high lands of Anwick, Digby, &c., west, is a tract of fen called by the Witham Act the *Fifth District*. With the exception of an "island" of high ground, stretching from South to North Kyme, the whole district is under artificial drainage, including South Kyme Low Ground and North Kyme Fen, east of the Car Dyke, and North Kyme Low Ground, Anwick, Ruskington, Dorrington, and Digby Fens, west of it. A part of North Kyme Fen drains into the adjacent district, called Billinghay Dales, and the rest is drained by windmills into Billinghay Skerth, an ancient river, running northeastward to the Witham. This main sewer likewise receives the water raised by the mills in the small western fens of this district, and empties it into the Witham, near Tattershall Ferry-Bridge.

North of Billinghay, bounded by the Car Dyke and the hills west, and the river Witham east, and reaching from the mouth of Kyme Eau up to Lincoln, is the *First District* of the *Witham Fens*. It is about 18 miles in length, and in the southern portion

* A steam-packet will shortly ply along the whole length of the Forty-foot, from Boston to Guthram Gote. Navigation and Drainage are not invariably, although frequently, at variance.

averages about three miles in breadth, containing upwards of 25,000 acres; and includes Billinghay, Walcot, Timberland, Martin, Blankney, Metheringham, &c. to Washingborough fens. Billinghay stands just at the point of a bold ridge of land which divides this line of fen from a part of the Fifth District, and prior to the inclosure and drainage of its fen in 1779, was nearly environed with immense lakes and pools of water, which, during a great part of the year, used to form almost "one uninterrupted and boundless extent of restless roaring waves." These waters contained large quantities of fish as well as, at certain seasons, abundance of wild-fowl of every description. Some of the fens were overgrown with "reeds and shards," amongst which the coot, and other small water-fowl, used to breed in great numbers. The inhabitants derived considerable profits from fishing and duck-shooting; and it is therefore natural that they should oppose any plan of drainage that would substitute day-labour for an independent mode of earning a livelihood, without giving any compensation for the removal of their privileges. Hence occurred riots and destruction of drainage-works, such as are found in the history of all the Lincolnshire drainages. When those fens were first embanked and drained, narrow tracts, called "dales," or washes, were left open to the river, and, like the fens before inclosure, liable to be flooded nine months in the year; but these have since been inclosed. The water from Billinghay Dales (which is much the largest of these plots), and the drainage from part of North Kyme Fen, are raised into the Witham at Dogdyke by a steam-engine of 30-horse power, erected there in 1841. The fens are divided by embanked upland rivulets or "delphs," into which upwards of 14 windmills formerly played, besides several that were built for draining the dales. The drainage, like the power employed to effect it, proved very uncertain and capricious, and continual losses were resulting from occasional floods and the general wetness of the land, when, in 1831, an Act was obtained for improving the drainage of Nocton, Potter-Hanworth, and Branston fens; and a powerful steam-engine was erected near the bank of the Witham. Since that period the whole of the "water-engines" (or wind-mills) have been superseded by the use of steam: Heighington engine drains the fens between the above district and Lincoln; Metheringham engine, of 25-horse power, drains the fens belonging to that town and Dunston; Martin engine, of 30-horse power, (more southward,) drains Martin, Linwood, and Blankney fens; the next is Timberland engine, of 30-horse power, built in 1839, which drains the fens of Timberland and Thorpe-Tilney; and thus every district, with its frontage of dales, is tolerably well drained by the indefatigable and faithful might of steam. Occa-

sionally the drain-banks give way, and cause a partial inundation; but the breach is usually repaired before much damage has ensued.

On the east and north bank of the Witham is a narrow but irregularly-shaped tract of fen-land, called the *Third District*, extending from the river Bain, near Tattershall, to the high lands of Willingham, near Lincoln. The low lands of Kirkstead have been greatly improved by the erection of a steam-engine of 30-horse power, which is employed in grinding corn, and in lifting water, when necessary. The next is Bardney engine, throwing also into the Witham. It is 35-horse power, and drains a recently-embanked district, named Stixwould Inclosure. When the Witham is full of water, this engine has to lift against a head of 9 or 10 feet. Further north, near the confluence of the Langworth river with the Witham, is another steam-engine, built in 1840, to drain certain lands in the parishes of Stainfield, Barlings, and Fiskerton, which had their drainage previously by several windmills.

There is also a considerable breadth of fenny land to the westward of Lincoln, through which passes the river Till. One catch-water drain defends it from the hill-floods of Burton and Carlton on the north-east, and another cuts off the high land water descending from Doddington, &c., on the south-west; the drainage being accomplished by means of two main drains connected with the Till and with the Sock-Dyke running alongside the Witham. The construction of the new Witham Channel certainly effected great improvements in the fen-drainage as well as in the navigation; but it was found that these conflicting interests quickly occasioned a serious dilemma, for as the water in the river was held up by two locks (one at Barlings and another at Kirkstead), the drainage was impeded; and if the water was run off to assist the drainage, the navigation was prevented. Accordingly, a new Act being passed in 1812, the two locks were removed, and a new one erected at Horsley-Deeps; and a sock-dyke or drain was cut along the south bank of the river, from Lincoln to a point just below the new lock, a distance of rather more than 8 miles; so that the water is always kept high enough for navigation between these points, whilst the side drain affords an uninterrupted passage to the upland and flood waters. By means of this work the low lands beyond Lincoln have chiefly a natural drainage, though previously little better than morasses. In the parish of Skellingthorpe, 2 small steam-engines have been erected near the Decoy Farm, to throw out the water in time of floods.

It is a question whether the First, Third, and Fifth Districts of the Witham fens will ever enjoy the advantage of a complete

natural drainage. If such is ever the case, it will be by a straightening, widening, and deepening of the channel through the town of Boston, accompanied by a much deeper excavation of the river between the Grand Sluice and Horsley Deeps, or a continuation of the Sock-dike to Boston, in order to provide for the navigation; for the conveyance of goods by railway between Lincoln and Boston will be a very long time in rendering superfluous a canal which admits coasting vessels from London, &c., up to Lincoln and the Trent. But the Witham, through Boston, has long been abandoned as an outfall by the great districts of fen on each side it, which might have aided such a project by their participation in the raising of sufficient capital to execute it; at any rate, an artificial mode of drainage must be followed as long as the interests of the Witham navigation remain worth supporting. However, if the sluice which holds up the water were removed, and the river deepened, so as to accommodate vessels, the engines would be materially relieved, and half their present work might most likely be dispensed with.

The improvements which have been made by drainage in all the great districts discharging by the Witham and South Forty-foot are truly wonderful. Prior to the opening of the new river Witham, in 1764, and indeed for some time after, the whole country, from Lincoln to Bourn, was often deluged by the expanding waters. The floods covered the entire surface from Boston to the high lands near Heckington, from Kyme to Tattershall, and on the north side of Boston, from Frith Bank to the northern hills.*

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* A writer, who lived in Kyme Fen about half a century ago, graphically describes the country thereabouts. He says, "Near the Garwick milestone

> "Nothing there grew beneath the sky
> But willows scarcely six feet high,
> And osiers barely three feet dry;
> And those of only one year's crop
> The flood did fairly overtop."

He adds, "I have times out of number seen cows loosed out of their hovels and swim across a river with nothing but their faces and horns above water, and then take footing at mid-rib deep, or less, but not one spot of dry land, and then forage till weary, and return to their hovels in the like swimming position. No place whatever was more famous for this than Chapel Hill, which I have known for a long continuance of years (previous to cutting the new river Witham, or, to speak more fully, opening the Grand Sluice) inaccessible but by boat, or riding horse belly deep, and more in water than mud. I have also known in the whole parish of Dockdyke not two houses communeable for whole winters round, and sometimes scarcely in summer; which was in some measure the case of all the water-side quite up to Lincoln. We used to carry the sheep to pasture in a flat-bottomed boat, clip them in ditto, and afterwards fetch them away in the same conveyance." With such a state of the country it is easy to see that the breeding and fattening of cattle was conducted in the rudest and most unprofitable manner, and the flocks were thinned by the rot; the animals being of the coarsest quality and the shaggiest covering that was able to preserve life in the greatest privations. The agriculture consisted in dairying and haymaking; and fishing and fowling trained up a race of inhabitants wild as the prey they lived upon, and destitute as their isolated huts could make them.

In the summer months these floods, of course, subsided. The condition of the surface at the present time may be judged from the facts already advanced: it is comparatively well drained and fruitful; and stagnant inundations with their pestiferous vapours are unknown.

The fens, east of the Witham, extending between Boston and the high lands of Tattershall, Revesby, &c., are termed the Fourth District. *Wildmore Fen* (next the river), and a greater part of the adjoining *West Fen*, drained by Anthony's Gout, about $2\frac{1}{2}$ miles above Boston, into the Witham; but the water in the river was often as high as the land itself, and instead of draining the fens kept their sluice-door penned up for weeks together.*

* The principal drains were those cut by the adventurers who drained these fens in the reign of Charles I. A slight sketch of that transaction is here added, because it explains the general tumults of the Commoners when enclosures have been proposed, and accounts for the popular opposition to the drainage of fens. The King "of his princely care for the advantage of the kingdom," by letters to the respective Commissioners of Sewers recommended the draining of these lands, himself being the owner of great quantities of the drowned lands. Accordingly these authorities (appointed by the Crown) taxed the country in order to provide a fund for the undertaking; but no payment being made, they contracted with Sir Anthony Thomas for the execution of the work. In four years he was to drain the district, estimated at 45,000 acres, so as not to leave more than 3000 acres under water; and was to receive a proportion of the recovered ground as his reward. Thus, without the consent of the proprietors of the soil, and the compensation of those numerous individuals owning rights of commonage, the King took away a large portion of their property as a recompense for the drainage of the rest. Sir Anthony accomplished the work sufficiently to procure his allotment, and the remainder was allotted partly to the King, and partly to the towns which had interest of common. In 1642 the commoners, dissatisfied with these proceedings, yet having no legal and constitutional means of expressing their discontent, took arms, broke the adventurers' sluices, laid waste their lands, filled up their ditches, spoiled their corn, and demolished their houses. A complaint was made to the House of Lords, who passed a bill for the relief and security of the drainers, "because of the advantage accruing to the King by the improvement of his lands from *4d.* per acre to 10*s.* and 12*s.* per acre yearly," and for repaying 50,000*l.* expended by the undertakers. The Commissioners had obeyed the wish of the monarch in opposition to the inhabitants of no less than fifty-two towns and villages, or 4000 families, having right of pasture and turbary in these fens; who now petitioned the House of Commons against the bill. They stated that by means of many chargeable gouts, drains, bridges, and other works of sewers, they had kept these fens fruitful and profitable ground so as to be the chiefest part of their livelihood; and that they were never "pestered with beggars and thieves" (as had been affirmed by the drainers) more than in the time of their undertaking. That only East Fen had been hurtfully overflowed, the West and Wildmore fens being then worth 10*s.* to 15*s.* per acre yearly. That the aim of Sir A. Thomas and his participants was to make prize of those lands, and that he had appropriated to himself the ancient drains, clows, sluices, &c. of the inhabitants, without making satisfaction for them. That the drainers had wrongfully taken away 8000*l.* *per annum* from the commoners, under pretence of raising 150*l.* yearly fee-farm rent for his Majesty's use. That the West and Wildmore fens were not in any way meliorated by the new works, but worse than they were before the undertaking; and that "equity of disbursements" need not be considered, for the profits of the parts the drainers had enjoyed seven years were (as themselves confessed) 57,000*l.*, which was more than they pretended to have laid out in the works, and many thousand pounds more than was actually expended. The commoners gained their suit, and retained possession of their ancient privileges. The state of these fens prior to the late drainage justifies the petitioners in their assertion that the country had not received an advantage proportional to the quantity of land taken away.

Like Holland Fen, therefore, these lands were obliged to forsake an adjacent river, and construct new drains to an outfall below Boston. This is called Maud-foster Drain, and now issues all the waters from the whole of these two districts, besides the floods from the hills beyond them. The drainage of *East Fen* was formerly by Good Dyke, &c., into Wainfleet Haven; but this outfall has been abandoned in favour of the Witham estuary,—so that the principal improvements in the drainage of the Lincolnshire fens have been made by conducting the waters of different districts to a common outfall, the separate water from each having proved unable of itself to overcome the silty obstructions thrown down by the sea. The lands are generally lower the more distant they are from the sea or outfall, hence great collections of water occupied the interior parts of these fens, as at that part of Wildmore Fen called "No Man's Friend," and the "Deeps" of East Fen and Wrangle Common, which were generally covered with water. Hence, also, the great expense that arose in forming proper drains to carry it off—the cuts being very deep in order to convey the water through the "Tofts" or lands of a higher level adjoining the sea. In a very wet season the outfalls were better than usual, because of the scour of the freshes; but in general, the quantity of silt settled in the river mouth, after a dry summer, was so great, that it required several weeks of the winter floods to wash it away. During that time the doors of the gouts used to be over-rode, and the fens became the receptacle not only of the water which fell on their own surface, but of all that which flowed rapidly down from the hills, and occasionally of an additional inundation from the bursting rivers; and owing to the badness of the drains and smallness of the gouts, the greater part of the spring was gone before the accumulated floods could be assuaged. At the latter end of last century various plans were suggested for providing a natural drainage for these fens, which the Witham improvements had failed to effect; and in 1802 the works were commenced, in pursuance of an act of the preceding year, adopting the system proposed by Mr. Rennie. From the levels taken it appeared that the surface of the water, in times when there was a full quantity in the Witham, was 3 feet 3 inches higher at Anton's (or Anthony's) Gout, than at the low-water of a neap tide at Maud-foster Gout; this decided the engineer to conduct the main drains from the former to the latter outlet. The general surface of the West and Wildmore Fens, except No Man's Friend, which lies about a foot lower, are about the same height; and thus he found that both might be drained by one outfall. Their surface was found to be about 3 feet above the low-water of a neap-tide at Maud-foster Gout, and at low-water spring-tide there was

frequently a fall of 4 feet 3 inches. The distance across the fen, along the principal drain, is $11\frac{1}{2}$ miles, which at neap-tide left about 3 inches fall in a mile, and at spring-tides $4\frac{1}{10}$ inches per mile. The fall, however, has been improved since that time by straightening the Witham outfall between this point and the Wash. The quantity of land in Wildmore Fen is 10,661 acres, of which 2947 are high lands: the quantity in West Fen is 16,924 acres, of which 5473 are high lands. There are nearly 12,000 acres of upland draining into the different becks, which pass through the fens and, from their great declivity, send down the floods very quickly in times of heavy rain. When the quantity of water which the brooks running into West and Wildmore Fens, including Hagnaby Beck, was measured, it amounted to nearly 22,000,000 cubic feet per day; but in times of great floods they often produce more than three times that quantity. The first amount, however, is sufficient to cover the low ground in these two fens (19,165 acres), about $\frac{3}{10}$ths of an inch deep all over the surface in one day. It was in this work that the principle of separating the upland from the fen waters was first carried into effect; and such was its success that numerous imitations have since appeared in the Lincolnshire fens and the more southern Bedford Level. The bulk of water descending by the above-mentioned brooks is entirely prevented from flowing into the fens by a catch-water drain, which cuts off their streams and conveys them, together with the drainage from the higher lands of Sibsey, Stickney, and Stickford, to the outfall at Maud-foster. As these waters descend rapidly, they must have an equally rapid discharge across the fen, or else a reservoir whose waters may be raised by their addition; but as the fen-drains have too trifling a fall to cause the water in them to flow quickly, the high-land floods by pouring into them would naturally raise the water at their upper ends, so as to impede the drainage and occasion floodings. To provide against these circumstances, the head of the catch-water drain (near the mouth of the Bain river) is 5 or 6 feet higher than the fen, and the fall of the drain (which is 21 miles in length) is about 6 inches per mile at low-water neap-tide, nearly double that of the main drains. Thus the running waters are furnished with the descent needful for their speedy delivery, and the sluggish fen waters have the sole advantage of whatever little fall they can obtain, whilst both meet on the same level where the land rises, toward the common outlet. The present Maud-foster sluice has three openings of 15 feet each, giving a total water-way of 45 feet; but the former gout was only 13 feet in the clear. The district drainage of West and Wildmore Fens may be described as thoroughly complete; the large drains (Howbridge, Newham, Medlam, &c., drains) being cleansed and

maintained by the Witham Drainage Commissioners, who levy a tax of 2*s.* per acre for that purpose; and the smaller sewers being superintended and well kept by the Fourth District Commissioners for an internal drainage-tax of about 6*d.* per acre.

East Fen has also a catch-water drain, which commences at Little Steeping, and after a course of 9 miles unites with that from the West Fen, several miles north of Boston.

The general surface of East Fen and Wrangle Common, at the time of the drainage, was about a foot lower than that of West and Wildmore Fens, and, taking the general distance of the fen at 13 miles from Maud-foster Gout, there remains a fall of only $1\frac{3}{10}$ inch per mile. From this it is easy to perceive why Mr. Rennie determined to conduct the East Fen waters to a separate outfall. Besides, the northern part of the fen, called the "Deeps," was always under water, the bottom of these reed-shaded lakes averaging $1\frac{1}{2}$ feet below low-water at Maud-foster, so that no drainage could possibly be effected by that gout. Since that time the surface has sunk by the drying and consolidating of the soil, so that if such a direction had been then chosen for the drain-water a new one would have been needed before the present time.

The old outfall of Wainfleet was useless; for, owing to the defective state of the channel the low-water mark was found to be 2 feet 1 inch higher at Wainfleet Gout than at Maud-foster.

About $2\frac{1}{2}$ miles below Maud-foster, or $3\frac{1}{2}$ miles following the bends of the river, is a place called Hob-hole, where, owing to the absence of shoals or sandbanks between it and the Wash, the surface of the water was found to be 4 feet lower than at Maud-foster; and it was therefore resolved to discharge the East Fen waters at this point. The fall from the bottom of the Deeps to this new outfall was 3 feet; the distance of the extremity of the fen is 16 miles, thus giving a fall of $2\frac{1}{4}$ inches per mile; but the rest of the fen lying 3 feet 6 inches higher, the fall from thence was nearly double. Accordingly, a new drain $13\frac{1}{2}$ miles in length was cut from this point, through the high marsh grounds into the lower East Fen, having proper side drains (as Fodder Dyke and Barlode, Bell Water, &c., drains) to communicate with it; and the sluice at Hob-hole was completed in 1806, the Maud-foster New Gout being opened in the following year. The quantity of land in East Fen is 12,424 acres, the whole of which, together with more than 26,000 acres of the East Holland towns (Wrangle, Leake, Butterwick, &c.), formerly draining by Maud-foster, now evacuate their waters at Hob-hole.

Such was the success of this drainage that a large extent of the marsh lands, north of Wainfleet, have diverted their water from the natural and adjacent outfall of Wainfleet Haven to the better

one of Hob-hole, though four times more distant. The river which supplies the Haven rises among the hills at Salmonby, and bringing down with it the water from Aswarby, Harrington, Partney, Raithby, &c., becks, passes with great rapidity into the fen. Before the great work of drainage now under notice was commenced, it was estimated that seven parts out of eight of this stream (called the Steeping River), went back into the fen instead of flowing through the Haven, and, consequently, the low lands of Steeping, Firsby, Thorpe, and Croft, were subject to dreadful inundations in wet seasons. An act was passed in 1818 for the more effectual drainage of the above parishes, together with Irby, Bratoft, and Wainfleet-All-Saints; and this embanked river was made to have a straighter course between Steeping Mill and Firsby Clough,* from which a new cut of 2 miles to Wainfleet saved a circuitous course of nearly twice that distance. The high land water of these parishes was thus separated from that of their low lands, the drainage of which (with part of Burgh) was conveyed by a culvert under the Steeping river into Bell-water Drain, communicating with the Hob-hole Drain.

Previous to the drainage, the East Fen was a wilderness of pools, bogs, and reed-shoals, and the low grounds of the contiguous parishes were generally flooded for six months in the year—the water seldom subsiding until May, or even later, and a part of the waters in Friskney were raised by a wind-engine, and sent to sea through a small gout. The whole of the fen, and a great part of the lands participating in its drainage, have now a generally good drainage, not being subject to overflow except in the very wettest seasons, or in times like the present (1850), when the tides flow several feet above their common level. The drainage taxes amount to 1*s.* per acre to the Witham Commissioners, and from 4*d.* to 6*d.* per acre for the management of the various interior drains. The lands surrounding the villages of Frieston, Bennington, Leverton, &c., are imperfectly drained, although on a much higher level than the well-drained commons on the north-west of them. The outfall is good, so that nothing is required but the providing of sewers of sufficient capacity, and keeping them in proper order—a duty much neglected throughout this neighbourhood.

Bounded south by the rivers Glen and Welland, and west and north by the Old Hammond Beck, is a tract of "old land" lying between the fen and marsh, including Gosberton, Donington, Swineshead, Wigtoft, &c. parishes, and the lower lands in the anciently reclaimed Bicker Haven. The principal sewers resemble ditches rather than drains, consisting of Old Ouse-Mer-Lode, the Five Towns Drain, Kirton Drain, &c., which wander

* Pronounced "clow," meaning a sluice where two or three streams meet.

with innumerable curves and branches in every possible direction except that of the outfalls at which they finally arrive. From the inadequacy of these sewers to carry off the amount of rain falling upon the land, and the circumstance that the lower ground only is liable to be wet in certain seasons, it may be concluded that the water finds another means of escape. The soak, or subterranean water, prevails throughout the district; and as the surface of the fields is absolutely without slope, the rain sinks directly downward, and forms the underground springs. The subsoil being remarkably porous, and the soak continually varying in depth from the surface, lead to the supposition that the excess of water filtrates to the larger rivers and the sea; at any rate, as there is but little land under-drained, the ditches must receive their water from the fields in this manner, and this supposition involves merely an extension of the same action.*

The southern parts have an excellent drain called Risegate Eau, running in nearly a straight line from Hammond Beck to the Welland near Fosdike. The chief outlets for the remainder of the district are the Hammond Beck (for a small portion), Fosdike Gout into the Welland, and Kirton Gout through the sea-bank. The marshes of Sutterton, Frampton, &c., also drain by these two gouts, besides having one or two smaller sluices through the sea-bank; the state of the drainage depending in a great measure upon the willingness of the occupiers to cleanse out their respective ditches for the accommodation of themselves and neighbours.

The narrow band of salt marsh between the mouth of the Witham and Wainfleet Haven is drained by sea-gouts through the frontier banks, of which every parish has one or more. The water is kept tolerably well off the land, so as to prevent its being flooded; but the drainage is not so complete and effectual as the nature of the soil requires.

The maintenance of the frontier banks round the whole of the marshes in this county is a costly labour, and a great burden to the frontage proprietors,—frequently occasioning a tax of 3*s.* or more per acre. Various calamities are upon record as having occurred in consequence of the breaking of the sea-barriers: one of the severest was occasioned by a gale and higher tide than usual, in November, 1810. The old banks were insufficient in height, and the surge dashed over them along nearly their whole extent, in its fall scouring away the soil of the bank on the land side from the crown to the base; by which means numerous

* Probably this is a reason why the atmosphere is healthy, notwithstanding the length of time during which the dikes remain full of standing water; the water, though apparently motionless, is not really stagnant, as it is being constantly, though imperceptibly, withdrawn and replaced by the gentle currents of the soak.

breaches were occasioned. In the town of Boston whole streets were inundated; and the whole extent of country from Wainfleet to Spalding shared in the disaster. Great numbers of sheep and cattle were drowned, corn and hay stacks swept away, and property to an immense amount destroyed. Subsequently to this the banks were strengthened and heightened, and made adequate to protect the country from tides of extraordinary swell; and though local inroads have occasionally happened since that time, there is scarcely a doubt but that in their present state they will generally be found sufficient for any emergency. The late extraordinary tides have thoroughly and satisfactorily tested them; the partial floodings of late having either been in the towns, or occasioned by the tides preventing the egress of drain-water;—in no case by a breach of the banks.

The different districts and systems of drainage in the great South-eastern alluvial tract having now passed under review, the next division of the county coming under notice is the breadth of low land called the *North Marshes*, stretching from Wainfleet to the Humber. The area of these marshes is large; but as the mode of drainage contains few peculiarities, a hasty sketch will suffice for the present purpose. The principal part of the waters from the great watershed of the Wolds and from the Clays reclining on their slope, descend upon the marshes, being the floods and springs from about 250,000 acres,—nearly three times the area of the marshes themselves. The waters have shaped out channels for themselves, being in some places embanked and guided by human art, and form the main drains for the low lands under the names of "cloughs," "eaus," "fleets," and "grifts." These issue through gouts in the sea-banks, which are closed at high tide. In some cases two or more of these straggling water-courses have been drawn to one outfall, in order to preserve, by means of their combined volume and velocity, a clearer and deeper channel through the wide flats and sands on this low shore. At Saltfleet, four of these drains, including one of the largest in this district, are discharged in one stream; and at Trusthorpe, Anderby, and Hogsthorpe, the same arrangement is observable. The drainage is a natural one, and usually considered as very excellent for a marsh district, having been greatly improved in almost every locality within the last ten or twenty years. Exceptions, however, must be made to this statement: the lands between Grimsby and Barton are not well-drained, the drainage of Barrow and the neighbouring parishes being very defective. As is the case in many marsh districts, this disadvantage arises from a neglect of the minor drains; and it is believed that in a country where each farmer is depending upon the efficient state of his neighbour's ditches for the drainage of his land,

there ought to exist more summary powers for compelling adjacent occupiers to cleanse their drains than costly and dubious actions at law.* Between Humberston and Louth, west of the Louth navigation, is a considerable breadth of ill-drained land; the water-courses pass beneath the canal, and at the enclosure of North Thoresby, in 1837-40, the drain-water was conducted under the navigation by an elliptical iron culvert 250 feet in length. On the east side of the canal are extensive tracts of lower ground called "fens." They formed unenclosed watery wastes or commons, but some of them (as Grainthorpe Fen) have been completely drained. Others termed "ings," belonging to various towns, yet remain (at particular seasons) in a wet condition. The low land between Carlton, &c., and the sea, appears to have been anciently partitioned by parallel banks extending across it, so as to defend the parishes from neighbouring floods; and both Great Carlton and Gayton-le-Marsh had each a wind-engine for pumping out their water. Eastward of Alford, though there are many small undulations of the surface, are some very low grounds, there having been in the parishes of Bilsby, Huttoft, Thurlby, Cumberworth, &c., no less than 10 windmills for raising the drain-water. The parishes of Burgh and Winthorpe have an outfall by gouts in the bank, but the bed of the sewer lying in a shifting sandy beach was frequently silted up, and the chief part of these parishes, with Skegness and Croft, now discharge into Wainfleet Haven by means of a new cut of three miles in length, executed fifteen or sixteen years ago.

The next drainage to be described is that of the *Ancholme Level.* The river Ancholme rises at Spridlington, on the oolite hills, and, flowing northward, receives at Glentham the river Rasen from the chalk hills at Tealby. It then continues along the flat for about 19 miles, and, augmented by numerous drains and becks from both east and west, issues by Ferraby sluice into the Humber. This long and narrow district contains probably about 28,000 acres that are below the level of high water spring-tides; the surface sinking gradually from about that level of elevation at Bishop-Bridge, to 4½ feet below it near Kelsey, about 9 feet at Brigg, and rising again to only 3 feet at Ferraby, under high-water mark.† It was very anciently embanked from the overflowings of the Humber; but the river had a very tortuous course, and was enfeebled and choked up by the alluvial deposits of the tides.‡

* It has been suggested that if the same powers were given against private individuals as are now given against Railway Companies for obstructing drainage, a great boon would be conferred upon the lowland farmer.

† The Section accompanying this Report is incorrect.

‡ In the reign of Edward II. the channel from Brigg to Ferraby, which had wont to be 40 feet broad, was much silted up, and in many places not 3 feet in width, the adjacent meadows and pastures being frequently overflowed and drowned.

Before the present direct channel was cut, there appear to have been no less than 12 or 13 elbow bends in the stream; and the lands were frequently covered by the fresh water, although there was not so much high-land water at that period descending upon them as now,—since the effect of enclosures, &c. is to increase the amount of water carried off from the surface, and almost all the uplands have been so improved in more modern times. The river was without any sluice at its mouth; consequently, its banks were very often broken by the force of the tides, and by the floods of fresh water descending its channel.

As this is a comparatively unknown district, a compressed account of the drainage works connected with it may be of interest to the public. In the year 1635 (10 Charles I.) Sir John Munson became the undertaker for draining the fens and carrs lying on both sides the river, and in partnership with the larger freeholders, who adventured for their own share, agreed to effect the drainage, and set a sluice or clow near the outfall, so that these grounds should become good meadow and pasture. A period of six years being allotted for the execution of the work, and 5827 acres assigned to Sir John and his heirs as a recompense, the work was performed, being completed in 1638. A channel nearly in a straight line was excavated from the Humber to Glentham Bridge, a distance of 18 miles, and several drains formed, leading to the new cut,—the lands between Elsham and Ferraby being drained by sewers made in the reign of Edward III., and having a separate outfall from that of the river. The level was adjudged to be sufficiently drained and recovered, and the portion allotted to the drainers; but, during that time when the whole nation appealed to arms for redressing grievances, the smaller freeholders and commoners forcibly entered again upon those lands, and the drains were filled up, the works neglected, and the sluices decayed. By an Act passed about 1767, the Ancholme was carried to its outfall in its present course, for the purposes of drainage and navigation; and the land which, before this improvement, was worth only from 1*s.* to 3*s.* 6*d.* per acre rental, was raised in 30 years to the value of from 10*s.* to 30*s.* per acre, —the annual expense amounting at that time to about 2*s.* 6*d.* per acre on 17,197 acres. The drainage, however, was not complete, and continued to grow worse instead of better, so that in 1801 the great engineer of the fens—Mr. Rennie—was employed to devise a more adequate system. His report was not adopted, and no improvement took place until 1825, when, under the recommendation of Sir J. Rennie, an Act was obtained, and the river straightened, widened, and deepened, so as to double its capacity. A new sluice was erected at Ferraby, having its sill eight feet lower than the old one, with a new lock 20 feet

wide, so as to serve the double purpose of admitting larger vessels and affording a greater discharge for the drainage-water during floods. The old bridges which obstructed the flow were removed, and a new lock formed at a distance of 18 miles from the mouth of the river. The sluice has three openings of 18 feet each, which, with the lock, give a clear waterway of 74 feet.* The effect of these improvements (the cost of which, amounting to 24,000*l.*, is defrayed by a tax on the land and tonnage on the navigation of the river) has been great: it was formerly a very dry time if persons could get across the flat on foot, but now (except at occasional seasons) the drainage is comparatively good. There is, however, a peculiar defect pertaining to the drainage of these carrs: whilst the side drains communicating with the river, and the minor drains and ditches of the whole level are kept clean and open, and the sluices in the river banks are in good order for issuing the water quickly, the head of water in the river is too high; and thus a district possessing a good fall at its outlet, and an efficient system of internal drainage, is frequently overflowed in wet seasons merely in deference to the rights of navigation. This narrow tract forms the natural reservoir for the drainage of 100,000 acres of the Wolds and intermediate high lands, 50,000 acres of the Cliff Hills, &c., and about 22,000 acres southward of that level; so that about 200,000 acres discharge by the Ancholme outfall, and the total bulk of waters daily poured through the river has been estimated at 140,000,000 of cubic feet, being sufficient to cover the entire level to a depth of 1·37 inches. The river is capable of readily emptying this quantity during the interval of the falling and rising again of the tide to a certain level, though the sluice is kept closed more than half the time; but as the navigation requires the river water to be about 11 feet higher than low-water spring tides in the Humber, the sudden floods are not evacuated with sufficient rapidity, and a defective drainage is the consequence. As the spring tides rise here to the average height of about 22 feet (much more in some instances), and the surface of the land is in the centre of the district 9 feet beneath high-water mark, there will be about 2 or 3 feet fall from the surface of the soil to the level of the water in the river, but at neap tides considerably less; and if this fall could be maintained a sufficient drainage would ensue.† But in order to receive the waters from uplands of six

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* Two sluice-gates were provided for each opening in the sluice: they are self-acting, being shut by the tide, and opened by the head of fresh water as soon as the tide falls below the level of the water inside. The openings are also furnished with draw-doors, for regulating the navigation level (which is 13 feet 8 inches above the sill), and to preserve a depth of 8 feet 9 inches at Brigg, which is nine miles distant, and 6 feet 6 inches at Haarlem-Hill lock, eighteen miles distant.

† The drainage of the northern parts of the level is assisted by small drains having

times the area of the flat without overflowing, the river ought to be kept as low as possible before the rains come on. As it is, the channel being sufficiently full before the floods descend, and the water from the southern extremity of the level having to flow 18 miles along a flat course, the water is raised by the high land streams above the surface of the land for some time before the sluice at the river mouth increases its discharge, and thus the carrs at Waddingham, Snitterby, Kelsey, &c., are often flooded for several days until the river subsides. This evil is mitigated in some degree by the perfection of the interior drainage, so that the water is not allowed to remain long upon the land after the river water has sunk to its proper level. These floodings, however, must occasion a serious injury to the soil and crops, and tend to choke up the few under drains which have been laid in some parts of the flat. A steam-engine has been erected to drain two parishes in one of the worst-drained localities, and its action has hitherto been attended with benefit. The district requires to be flanked on both sides with adequate catch-water drains, formed at a higher level than the main drains, and arranged with separate sluices for discharging into the Humber. These might also be employed to feed the navigation and to irrigate the level when requisite.

This system of separating the drainage of the high lands from that of the low lands was recommended by Mr. Rennie in 1801, founded on the observation that the greater force and rapidity with which the water from the upper districts reached the river than those from the lower had the effect of driving the latter over the level, the sluices being inadequate to discharge the entire bulk of water during the periods while the tide permitted the sluice-doors to remain open. If catch-water drains were constructed along the whole level on each side, considerable advantage might be gained by adopting the further recommendation of Sir John Rennie, viz. the formation of reservoirs, with overfalls and weirs to receive the sand and mud brought down from the upper part of the country, and thus prevent its accumulation in the river. There is an ancient sewer running from Ferraby towards Elsham, which intercepts the water-brooks from the hills, but the low lands have likewise to drain by it; and as there is a breadth of very wet and rushy land between it and the hills, near Ferraby, Horkstow, Saxby, &c., a drain is still needed on a higher level to prevent the Wold waters from descending to the vale. The Ancholme carrs are also subject

separate outlets, but the rising of the tide causes a loss of time for discharge, and floods are not unfrequent. In Worlaby carrs 50 acres of wheat were so much destroyed in the autumn of 1848 that it had to be sown again in the next spring, quality and quantity greatly falling off.

to occasional inundations of the Humber, and the barrier-banks are attacked by the tides in a peculiar manner. The sea-banks along the whole Lincolnshire coast, and the long lines of embankment which restrain the fen rivers, are subject to the wearing action of the waves and the pressure of water; but in a modified degree. The Wash rivers bring the drainage from above 5000 square miles of country, extending into Leicestershire, Buckinghamshire, and Suffolk, and issue into the centre of a broad bay, these floods with the sea-water being warded off from the land by immense flats of sand. Thus the shore at low water presents a beach from 2 to 3 miles in width, and it is only at high tide that the banks are subjected to the power of the waters; if, therefore, they are of proper strength and dimensions little danger is to be apprehended. So along the chief part of the coast washed by the open sea, the banks are protected by wide foreshores of sand and marsh; but with the embankments on the Humber the case is very different. The Humber rivers radiate to Westmoreland, Staffordshire, and Leicestershire, draining a much greater expanse of country than that drained by the Wash, and discharge through a winding estuary rather than into a bay. The sands, instead of fringing the marshes, have been precipitated by the muddy waters in the middle of the Humber, forming the great banks or shoals named Whitton Sand, Old Warp, Skitter Sand, &c., and the water dividing flows by two deep channels between them and the land on each side. The Ancholme marshes are situated just at a bend of the estuary, opposite to a projecting point of the Yorkshire coast, which serves as a jetty to direct the full force of the current against the banks. The channel being so near to the banks, the effect of the scour upon them is very great; and, besides this, the tides flow in at the rate of about 8 miles per hour, and as a velocity of 2 miles per hour is sufficient to transport along the bottom of a river stones the size of an egg, the eroding power of this current may be readily conceived. This scour, together with the beating of the waves, eats away and undermines the soft warp soil upon which the embankments stand; and when the water has encroached to the foot of the bank it becomes of little consequence what is the size and strength of the mound, for the land settles, the tides overtop the bank, and breeches and flooding occur. It is only by strict attention to repairs outside the embankments that large encroachments of the Humber can be avoided: where this is neglected, the banks are gradually destroyed, and the new ones that are erected have to be fixed backwarder on the land.

Along the east bank of the river Trent is a breadth of land several feet lower than the water in the river at high-tide, and

containing probably about 9000 acres. The chief natural watercourse is the river Eau, descending from the Cliff and other high land by Corringham, Scotter, &c., to the Trent near Butterwick. The drainage is chiefly a natural one by means of numerous drains emptying by sluices into the river at low tide. From Butterwick to Trent Fall the river ebbs sufficiently low to allow the drains to discharge their water without artificial aid, but this is in consequence of the soil having been warped to a considerable height, and thus elevated above the level of the Trent waters. The drainage is generally good, but there are extensive tracts that have not been raised sufficiently high to be out of the reach of floods, and the southern part of the district possesses 2 steam-engines for lifting the water. In the angle of the Trent, immediately north of Gainsborough, is a district of about 2600 acres, called Morton Carr, originally a very low and worthless tract of common, but now warped and drained. At the close of last century the work of improvement was begun; catch-water drains were constructed under the high lands which surrounded and divided the Carr, and warping-drains were excavated across it. The lower grounds had only a 2-feet fall to low-water mark in the Trent at Ravensfleet; but the land was warped up several feet by artificially directing the muddy overflows of the river. This land, lying in the townships of Morton, Walkerith, East Stockwith, Blyton, Wharton, Pilham, and Gilby, was enclosed and drained under an Act passed in 1801, but the drainage being defective, a recent Act was obtained a few years ago, and a powerful steam-engine was erected to assist the discharge of the water.

The river Trent bounds the western side of the county, from Newton to Stockwith, by a tortuous course of 20 miles, and then enters the county, dividing the district last noticed from the *Isle of Axholme* for a similar distance, until it unites with the Ouse and flows onward into the Humber. This broad stream, bringing the floods from the counties of Nottingham, Leicester, Derby, Warwick, and Stafford, receives the river Idle at Stockwith, and afterwards the drains from the low lands of Yorkshire, and carries away the waters from about 80,000 acres of the lias valley and the hills eastward, and from about 50,000 acres forming the Isle of Axholme westward. This district consists of about 30,000 acres of low land surrounding about 20,000 acres of uplands, which rise like islands out of the broad horizontal plain; being the Lincolnshire division of an immense breadth of flat land lying in the three counties of Lincoln, Nottingham, and York.

The history of the drainage of this level is remarkably interesting, both to the engineer and agriculturist; but there is not

room here to notice anything more than the more important circumstances connected with that work. Commissioners were appointed to view and repair the banks and ditches of this tract as early as the first year of the reign of Edward III. In the 6th of Henry VI. a public statute was enacted, prescribing a form for the guidance of all Commissioners of Sewers according to the laws and customs of Romney Marsh in Kent, and the few drainage works in this district were for a long period maintained by various commissioners acting under that law, which gave them powers, not only to make ordinances for the conservation of the banks and marshes, but also to impress ditch-makers and other labourers upon competent wages in cases of urgent necessity. Notwithstanding these regulations, this district, prior to the reign of Charles I., was for the most part covered with water. No less than 60,000 acres were continually overflowed, so that, even in summer, the water was 3 or 4 feet deep. Boats laden with "corn and plaster" passed over the land between the Idle and the Trent—"men rowing also with lesser boats to look swans over all parts of it, betwixt Lammas and Michaelmas." These extensive wastes, instead of yielding profit to the state, "nourished beggars and idle persons;" and the King had a chase of red deer ("Hatfield Chase") through a large part of this fen, which much annoyed and oppressed the residue. King Charles I. was lord of the Isle of Axholme, Hatfield Chase, Dikes-Marsh, and the lordships of Wroot and Finningley; and, to increase his revenue by reclaiming this great quantity of drowned and boggy ground into good meadow, arable, and pasture, contracted with Cornelius Vermuyden (a Dutch engineer) for the drainage of the level. The inundation was chiefly owing to the situation of the land, which was lower than the high tides of the Trent, and was intersected by the rivers Idle, Thorne, and Don, and the sewer called Bycar's Dyke; but the upland waters were also compelled to overflow by the impediments of silt contracted in these channels by the daily tides. The drainage was performed in the space of five years, at a charge of 55,825*l.*, the fresh waters which usually overflowed the whole flat being conveyed into the Trent through Snow sewer and Althorpe river, by sluices which issued out the drain-water at every ebb, and kept back the tides at their flow. A proportion of land was allotted to the King; and Vermuyden, together with his participants in the work, received a third part of the lands (*i.e.* 24,500 acres) as a recompense; a corporation or company of adventurers being established for the perpetual maintenance of the works by charges upon their lands. According to the drainers, great advantages accrued from this undertaking (which preceded the drainage of the Great Bedford Level); a great part of Haxey Carr was

sown with rape and corn for three years together (not being deluged by either tides or freshes), and bore plentiful crops. A portion of that low swampy district, not worth 6*d.* an acre previously, was after the drainage worth 10*s.* an acre. Houses were erected in many parts of the level which had been drowned land, and after the improvement the grounds were better worth 13*s.* 4*d.* per acre than 2*s.* an acre before. Fifty quarters of rape-seed were obtained from 10 acres of the drained land in one year, and sold at 30*s.* per quarter: and these watery wastes became so well dried and fitted for cultivation that the usual yield per acre was 3½ quarters of wheat, 3 quarters of rye, and 8 quarters of oats, and in some cases 7 quarters per acre for six years together. Though this can only refer to a small area, it shows the skill of the husbandmen of that period, and also the natural richness and productiveness of the soil. The tribe of wandering beggars, we are told, in a great measure disappeared, the hands being set to labour in weeding corn, burning earth, threshing, ditching, harvest-work, and other operations in husbandry—the wages of labourers in the neighbourhood being doubled by reason of this increase of employment. Two hundred families of French and Flemish Protestant refugees settled in the district, and ploughed and tilled much of the Adventurers' lands until the year 1642, when the tranquillity of the Isle of Axholme, like the peace of the whole kingdom, was broken by the outbursts of popular indignation. In this case, as in the lamentable outbreaks which occurred in almost all parts of the Lincolnshire and other fens, the commoners, taking advantage of the disturbed condition of the realm, sought by riots and tumults to regain their turbary, pasture, and arable ground, as well as the privileges of fishing, fowling, and hunting, of which they had been bereft, and the result was the destruction of the adventurers' works which had injured instead of benefiting the commons.* At the close of the

* The nature of these occurrences appears from the following statements. The King, being desirous of improving the lands which contributed to his revenue, issued a commission to certain gentlemen to treat and conclude with those who claimed common of pasture, by way of composition, in land or money; and those who would not agree had an information exhibited against them in the Exchequer Chamber by the Attorney-General, and were obliged to submit to his award. There were no less than 370 commoners in the manor of Epworth alone; and of 13,400 acres in that manor, 6000 acres lying next to the towns (now called "Open-field lands") were allotted to the commoners as their portion, and the remaining 7400 acres to Sir C. Vermuyden and his participants for their third part and for the King's part. This does not seem to have been an equitable arrangement, but the cause of dissatisfaction was, that the whole of those who had interest of common were compelled to sell their rights and agree to the drainage, no matter what was their opinion as to the benefits they should derive: and it is matter of fact that the number of those who dissented from the undertaking were three

last century, under the powers of an Act passed in 1795, the drainage and enclosure of a greater part of the Isle of Axholme and other districts adjoining was effected on a much more adequate and permanent system than that which guided Vermuyden's improvements. Several large drains were executed, which are now used both for draining and warping the land, a clause in the Act permitting adjacent proprietors to employ them for the latter purpose. The canal running westward from the Trent at Keadby was also constructed about the same time, having a soakage drain on each side of it for draining the country, and for delivering warp on each side for several miles inland; and, in case these side-drains should at any time be warped up by the sediment, sluices were provided to let water out of the canal to scour them out clean.

The general surface of the low land in the Isle of Axholme sinks as it recedes from the river Trent, and is several feet lower than the level of high-water. The highlands, which constitute

times as many as those who agreed to it. The whole scheme was merely a device for replenishing the monarch's purse; and though it might create a demand for labour, and place the poorer commoners in more comfortable circumstances, still it was like administering a distasteful medicine against their will, and while inducing more comforts it destroyed their independence, reducing them from the freedom of self-maintenance to a state of dependent servitude. Accordingly, when the Parliament itself had set the example of denying the omnipotence of the Sovereign, the inhabitants insisted on again having their rights of common, refusing to be any longer bound by the King's decree. In keeping with the manners of the times this demand was enforced by arms,—they arose in tumults, broke down the fences and enclosure of 4000 acres, destroyed all the corn growing, and demolished the houses. The flood-gates of Snow sewer were drawn up, which, by letting in the tides from the Trent, soon drowned a great part of Hatfield chase. This was done for seven weeks together, men letting in the tide at every full water, and keeping the sluice shut at every ebb—"divers persons guarding the sluice with muskets, and saying that there they would stay till the whole level were drowned and the inhabitants forced to swim away like ducks." Another sluice near Misterton having been pulled down, the river Trent broke down the banks and overflowed the whole level, so that the barns and stacks of corn were flooded to at least a yard in height. This work of destruction is on too extensive a scale to be considered as mere mischief, and evidences a widely-spread discontent among those who had held rights of commonage. In 1645 the inhabitants of the Isle of Axholme threw down a great part of the banks, and filled up the ditches, putting cattle into the corn and pastures of those that had been adventurers for the draining. A petition of the participants against these outrages states that after the expenditure of at least 200,000*l.* in those works, the tenants of the manor of Epworth had laid waste at least 74,000 acres of land, and destroyed a great quantity of rape and corn growing, by forcibly keeping and depasturing their cattle thereon; also demolished very many houses, burnt others, cut and burned the ploughs, beat and wounded those that were ploughing or offered them any resistance, and resisted the participants in levying taxes for the repair of the works. The aim of the rioters was to obtain possession of their ancient commons, and the whole of their proceedings demonstrates that, however advantageous the drainers may have represented the work to be, the persons who possessed the first claim to profit would much rather have retained their olden privileges and habits of living. Disturbances were continually kept up until 1714; and what the forces of the army had been unable to quell, seem to have been quieted at last by an Act of Parliament against rioting.

about two-fifths of the whole district, occupy the central parts, and (with an interruption of low land between Crowle and Belton) stretch in swelling hills between Crowle and Haxey, dividing the low land into two portions, the lowest of which is on the western side. The general drainage of the flat is westward from the Trent Bank to the Folly Drain, New Idle Drain and others, which traverse the lower grounds, and then empty into the Trent at and near Althorpe. The northern part has main drains emptying into the same river. In consequence of the slope of the surface away from its outfall, the natural rivers (as in the southern Fens) had to pursue a circuitous course in order to discharge, as may be seen by the remaining channel of the old Don, and Vermuyden began his work by cutting straight drains to conduct their waters; but he fell into a great error,—that of conducting the drainage-water to the wrong outfall. Probably from omitting to take levels of the country, he chose Snow sewer and Althorpe sewer for his chief outfalls; but as these outlets are many miles above Trent-fall, and as the river has a fall of 6 inches per mile nearly all the way down, a considerable fall,—enough to make a complete instead of a bad drainage,—was lost. If he had taken his principal drain to the broader river Ouse there would have been 5 or 6 feet better fall, because the fall from the outlet sluice to the Humber would have been so much less; and there would have been a natural drainage for the western and southern low grounds which have been forced by this unfortunate blunder to adopt an artificial drainage.

The lower part of the Isle of Axholme, adjoining the lower levels in Yorkshire, previous to the introduction of steam-engines, was principally drained by small scoop-wheels worked by horse power. Almost every farm possessed one of these machines; but the drainage was very imperfect, and was attended with a great waste of horse-flesh. In moderate rains the farmers were able, by these means, to keep the land tolerably clear of water; but if the rains were of any long continuance horse power proved ineffectual, and the low lands were frequently inundated for a considerable time. Windmills, which formed the first means of artificial draining universally employed in the great Bedford Level and the fens of South Lincolnshire, have never been used for that purpose in this district, probably owing to the preference of the occupiers for a system entailing great expense and inconvenience rather than for a method which, though comparatively cheap, is often entirely useless during the wettest and most urgent seasons. Within the last twenty years the steam-engine has been introduced: during the last three or four years

there has been a great extension of this powerful and unfailing agent as a means of drainage, and it is thought that steam-engines will become general throughout the district. It is commonly supposed that the scoop-wheel, such as is usually worked by windmills, is inferior to the pump, but in the Isle of Axholme it is found to be otherwise. At one period lift-pumps were employed in connexion with the steam-engines, but they were expensive, troublesome, and liable to get out of repair, and besides this they would not perform half the amount of work that the wheels will. At the present time there is only one engine that works a pump—viz, Sir Robert Sheffield's, at Butterwick,—and this, owing to the inefficiency of the pump system, and insufficient power of the engine, is quite inadequate (we have been told) to perform the duties required of it. For a description of a scoop-wheel the reader is referred to the cut at the close of this section. The size of the wheels varies according to the height of the head of water against which they have to throw, the quantity of water to be lifted, and the power of the engine. When the wheel dips 5 feet below the drain-water level, and the level of the water in the receiving drain is 5 feet above that in the delivering drain, the diameter of the wheel should be 28 or 30 feet; and if, with the same dip, the head be 10 feet, the diameter ought to be 35 or even 40 feet. The reason for this is, that the space between the ascending float-boards remains charged with water until it reaches the surface of the water in the river or reservoir; and if this surface be higher than the wheel-axis, or centre, the boards will be unable to shoot off all the water they have raised, and will consequently allow a large portion to fall over again into the trough from whence it was taken. As respects the horse-power per acre required, that depends upon the height to which the water must be lifted, and the suddenness of the floods which limit the time in which the work must be performed;—it is calculated that as water weighs 10 lbs. per gallon, a horse's power will raise 330 gallons, or 52·8 cubic feet, 10 feet high per minute, and that a steam-engine of 10 horse power will raise and throw off the drainage water due to a district of 1000 acres in each month, in about 20 days, working 12 hours a day; but the actual horse-power and expense per acre for coal, &c. under different circumstances, must be sought in the details given in this report and the "Report on the Fens." *

The following are estimations of several particulars concerning the steam-engines in this level:—

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* Journal, vol. viii.

Name of Engine.	Acres Drained.	Horse-power.	Engine used.	Extreme Lift.
				Feet.
Soss Engines	6000	80	Scoop-wheel	10
Heck-dike Engine. . .	1000	15	,,	10
R. J. Atkinson's . . .	400	8	,,	4
Kelsey's	300	4	,,	4
Low Level	300	5	,,	4
Belk's	150	5	,,	4
Jaques'.	100	3	,,	4
Broughton's	1000	20	,,	4
Hirst Priory	5000	60	,,	8
Butterwick	600	20	Pump . .	8
Kelfield	100	5	Scoop-wheel	6
Carr's	300	8	,,	4
Wm. Pearson's . . .	200	8	,,	4
Newland	400	16	,,	4
Gervase's	300	5	,,	4

The Soss works of drainage have two engines of 40 horse-power each, draining a district of about 6000 acres. The engines drive two large scoop-wheels capable of lifting the water up to 12 feet; the outfall is the river Trent at Stockwith. In time of floods the river does not ebb out so low by 10 feet as at other periods; when this is the case the engines on the main drains have to lift the water from 8 to 10 feet. The Heck-dike engine has also its outfall in the Trent, and has to contend with difficulties similar to those of the Soss works. These engines drain a district of land in Nottinghamshire, but immediately adjoining the low levels in the Isle, and in fact forming a part of the same level. The Hirst-Priory engine (about 1½ miles south of Crowle) drains about 5000 acres, lifting the water into one of the main drains which has its outfall in the Trent at Althorpe. These constitute the public steam-engines; the remainder of the engines are small ones, erected for the purpose of draining small districts or single farms. They lift their water into the nearest drains communicating with the river Trent, and are not required to raise the water more than 4 feet at any time. They serve their respective districts better than the larger engines do theirs, and are more economical. The cost per acre of the steam drainage of course varies materially according to the season and the nature of the weather: in winter the downfall is greatest, and the evaporation least, and in summer *vice versâ*; so that the chief part of the work is effected during the former portion of the year—the amount of water thrown out, and consequently the proportion of expense incurred, depending entirely upon the relative degrees of downfall and evaporation throughout the year. Some years, therefore, bring heavier charges than others; but the average cost will be from 2*s*. to 5*s*. per acre. Steam power,

as before observed, is likely to be adopted over a much greater portion of the level than at present: for besides being necessary for the good drainage of the low sand and peat which lies too far from the Trent to be raised by the process of warping, in some cases the warped lands themselves, though their surface has been heightened from $1\frac{1}{2}$ to 3 feet, and of course has a better drainage than the land not warped, will not be effectually drained without mechanical assistance.* In some parts of the level during dry seasons water is admitted from the high-level drains, and in the present condition of the drainage in those localities this supply is found to be useful and advantageous. There is now an excess of moisture in winter and a scarcity in hot weather, so that plants are rendered sickly by the damp atmosphere and saturated earth of one season, whilst their dry leaves are parched by the heat and their roots suffer a famine of liquid food during the other. Owing to the wetness of the soil, the particles in drying come into such close cohesion that the mass in a great measure loses its capacity for retaining moisture, the ground becomes parched and arid in the summer, and vegetation can find no nutriment; to refresh and vivify the crops the lands are then fed with water from the drains, and an immediate benefit ensues. But if the soil were never allowed to fill itself with cold moisture, and the water in the ditches were kept 3 or 4 feet below the surface all winter; if the subsoil, no matter how loose and sandy, were thoroughly well under-drained to the same depth; would not the soil preserve during the summer that segregation of particles which enables it to hold moisture, and, instead of pinching and stunting the root fibres, present a free and nourishing medium for their growth? This inquiry may hereafter be answered in the affirmative by those who shall experience its truth, for though it must result from a natural drainage, it is not, therefore, a desideratum out of reach, there being no physical obstacle to the draining of this level by the natural fall of the waters to sea. Steam has effected, and will yet effect, great improvements here; but the "only perfect system" of drainage is certainly prac-

* For the information of those who have occasion to make use of steam-power for draining their farms, the following estimate, by a very intelligent occupier in the Isle of Axholme, is here subjoined. The engine which drains his farm of 400 acres is a portable one of eight horse power. He uses it for thrashing corn, and when requisite takes it to the scoop-wheel, which, with its driving machinery, is permanently set down. The cost per acre for drainage alone is thus computed:—

	£	*s.*	*d.*
Cost of engine and driving gear, scooping-wheel, &c., 250*l.*, at 10 per cent.	25	0	0
Coals, 10 tons at 10*s.* (amounting only to 3*d.* per acre)	5	0	0
Wages, oil, tallow, &c.	5	0	0
400 acres at 1*s.* 9*d.* per acre	£35	0	0

ticable, and perhaps advisable. The following is the opinion of one whose kindness has furnished the chief facts that have been adduced respecting the Isle of Axholme :—If a large main drain were cut from "Idle-stop" to the conjunction of the Trent and Ouse with the Humber at Trent fall, it would effectually drain the whole neighbourhood comprised within the Isle levels, as well as the adjoining lands in Yorkshire and Nottinghamshire. This drain would pass through the lowest lands in the district, and its outfall would be at least 10 feet lower than that at Althorpe; it would also possess the natural advantage of having no fresh water except its own to contend with. The Trent being narrow at Althorpe, the freshes rise to a considerable height; whereas at the Trent fall, where the junction with the Humber is effected, the area of the river becomes very great, and the freshes have very little effect in varying the ebb or level of low water. The drain, if cut, must be a tidal one, and not less than 200 feet wide at the bottom. The water should pass into it from the minor drains by means of self-acting sluices. The water from Bawtry (in Notts) now passing through Bycar-dike to Stockwith, would enter it at Idle-stop, and would, with the assistance of other inlets, be sufficient to keep the new river open and cleansed. The new river, being a tidal one, would be used with great and perfect success in warping the adjoining lands, more than 20,000 acres of which might be warped by it, which *cannot be done by the river Trent.* This opinion accords with the Reports of Smeaton in 1776, of Rennie in 1813, and of a committee appointed in 1828; the latter projecting "the complete drainage of more than 100,000 acres, the warping of 15,000, which would alone add 20,000*l.* a year to their value, and procuring a navigation to the whole," the estimated expense being 350,000*l.* It is for the proprietors to determine whether the immense advantages accompanying a good natural drainage, and the creation of so vast an amount of fertility by the process of warping, would not remunerate them for the outlay required in such an undertaking.

This imperfect sketch of the Lincolnshire drainages has unavoidably occupied a large space, but simply because the subject could not be treated with justice within narrower limits, its importance claiming a separate report for itself. Although this county comprises within its borders but a very small portion of the Bedford Level, it possesses an immense extent of low land on a dead level, below the tides of the ocean, and divided into a variety of districts, each with its peculiar contrivances and great works of drainage, such as have now passed under consideration; and when we consider the extent of the contiguous flats of Holderness, Walling Fen, &c., in Yorkshire, of the Bedford Level, of the East Norfolk lowlands, &c., what a magnitude and mul-

tiplicity of works, and what a number of skilful appliances, are to be found in the whole extent of marshes and fens in the eastern counties of England! But Lincolnshire, when taken alone, contains subjects of great interest connected with its low lands, especially its long and firm embankments, its immense excavations of drains and rivers, the great works of its improved outfalls, the employment of horses, wind, and steam for drainage, and the formation of new land stolen from the tides. It is a gratifying fact, that, while the men of Lincolnshire have gained renown by their skilful high land management, they have at the same time defended from the sea a tract equal to nearly one-third of all their county: so that, if the banks were to be thrown down, Lincolnshire would be reduced to the figure and dimensions represented by the coloured portion of the map accompanying this Report. It is pleasing also to view the systems of artificial drainage, where the tall smoke-breathing chimney and the massive machinery give an air of manufacturing industry to the labours of agriculture, impressing upon the mind the fact of husbandry being in effect the fabrication of meat and bread from raw inedible materials by the toil and ingenuity of man.

With regard to the aggregate amount of wind and steam power now in use in Lincolnshire for the purpose of drainage—there will probably be less than 10 wind-engines when the Black Sluice improvements are completed; at present, in the Witham fifth district and the Black Sluice drainage, there are about 40 windmills at work. The precise number of steam-engines has not been ascertained, but the following estimation is near the truth:—

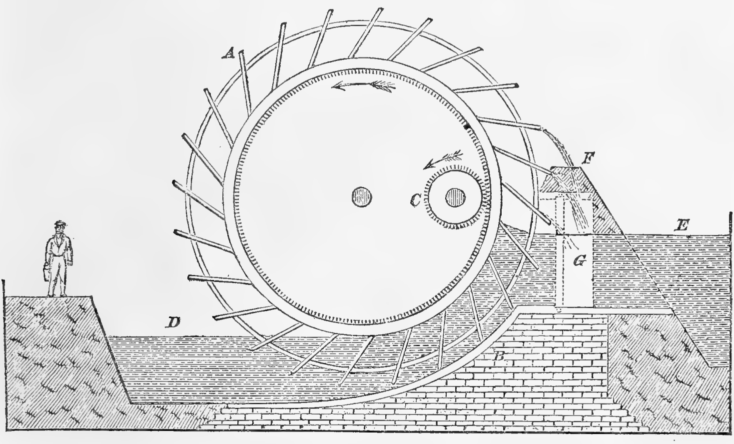
Locality.	Number of Engines.	Variation in Power.	Combined Power.
Deeping Fen	3	10 to 80 horses.	150 horses.
Pinchbeck Fen	1	. .	20 ,,
Spalding and Pinchbeck . .	1	. .	20 ,,
Bourn Fen	1	. .	30 ,,
Witham Fens, &c.	11	10 to 40 ,,	270 ,,
Ancholme Flat, Isle of Axholme, and low lands east of Trent.	18	4 to 60 ,,	320 ,,
Total number of Engines	35	Aggregate power, 810 horses.	

There are upwards of 35 steam-engines, having an average power of about 22 horses each, draining nearly 80,000 acres of land, and lifting the water from 3 to 12 feet high, on an average

about 7 feet.* The lands thus drained therefore resemble the Polders of the Netherlands, on a smaller scale, but much more effectually drained; the water being there elevated in successive lifts to the height of 20 or more feet, from millions of acres of embanked lands; but with this disadvantage, that the motive force is wind instead of steam.

In Arthur Young's "Survey" of this county, in 1799, it is stated that there were at that time 66,000 acres of low lands not begun to be drained; but at the present time all the fen and marsh lands enjoy what Young would have thought an exceedingly good drainage, and there are constant improvements going on which give a promise of the time when a deep and permanent subsoil-drainage will become practicable and universal.

Explanatory Drawing of a Scoop-Wheel.



A, Scoop-wheel 33 feet in diameter, making three and a half revolutions per minute. The float-boards are 5 feet in length, and may be from 20 inches to 5½ feet in breadth, according to the power of the engine and the head of water, &c. to be provided for. The lower half of the wheel is encased between two walls, just far enough apart to admit the floats between them.

B, Curve of masonry fitting close to the ends of the floats, and (with the side walls) forming the wheel-race.

C, Pinion upon the crank-shaft of the steam-engine, gearing internally with a toothed wheel on the side of the scoop-wheel. It is more common to have a smaller pinion working a separate toothed-wheel on the axle of the scoop.

D, Main drain, 9 feet deep. The water-level is 3 feet below the surface of the land when the wheel has its full dip (5 feet), and there is 1 foot in depth left below the floats or ladles for the passage of weeds and other matters.

E, River; the water 8 feet higher than that in the drain, and therefore 5 feet above the land. This "head" of 8 feet, with the "dip" of 5 feet, make 13 feet "head and dip." If only half the length of the floats was immersed, the "head" would be greater, and the "dip" less; but the "head and dip," or extreme height to which water is lifted, would be the same.

F, Embankment.

G, Pair of doors on valves, pointing like the gates of a canal lock, so as to prevent the water in the river from flowing back upon the wheel when the engine is at rest.

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* It must be borne in mind that these figures refer solely to this county. If the Bedford Level be included, the total area under steam drainage will be something like 220,000 acres; the number of steam-engines about 80; besides about 210 wind-mills draining other lands.

3. *The peculiarities, whether advantageous or defective, in the agricultural management.*

The general farming of Lincolnshire has been affirmed by an intelligent observer to be superior to that of the far-famed East Lothian, and mainly because the barren wastes of the former have been artificially made to emulate the native productiveness of the latter district; and if the luxuriant grazing lands constitute "the glory of Lincolnshire," the Heath, Cliff, and Wold hills must be considered imperishable monuments of the energy and ability of its cultivators. Mr. Pusey, in his paper on the agricultural improvements of this county,* has contrasted the state of these high lands in 1842 with what it was prior to 1800; but a repetition here of some of the facts is absolutely necessary, in order to give a just distinction and prominence to the merits of the farming in 1849, as now to be detailed. Although the oolite limestone and chalk ranges are entirely disconnected and distant from each other, still, as they have undergone a contemporaneous improvement, and exhibit a similarity in their systems of husbandry, it is proposed to notice them successively, and afterwards to describe the farm management of adjacent districts.

The chalk *Wolds*—which, constituting much the largest and most important district, demand the first attention—were, in the middle of the last century, a succession of rabbit-warrens from south to north. Fifty years ago they had been so far improved that many thousands of acres of open field were subdivided by enclosures, and the four-field system of cropping had established itself over large breadths of land. Still, warrens overspread a wide tract of the loftier hills, and the surface was covered with gorse for many miles. Fences, however, have since then extended rapidly in every direction, and all the open fields have disappeared, a great part having been enclosed within the last thirty years. The gorse has been grubbed, the rough sward burned, and all the warrens, with one or two exceptions, have been brought into good cultivation. No portion of the ground has been allowed to remain (as on the Downs of southern England) a tract of sheep-walks in its primitive vegetation of heath and fern, but the highest points are all in tillage, and the whole length of the Wolds is intersected by neat white-thorn hedges, the solitary furze-bush appearing only where a roadside or plantation border offers an uncultivated space. And the whole of the improvements have been accomplished on a grand scale: the holdings are large, there being scarcely a single farm under the size of 300 acres; many contain 800, 1000, 1500, and more acres, and there is one

* Journal, vol. iv., 1843.

(the Withcall estate) of 2300 acres.* The fields are all of a proportionate magnitude, varying generally from 30 to 100 acres, presenting to the eye of a stranger the aspect of open-field lands, the fences being often concealed by the surface swelling into hills or descending steeply into deep hollows. There is only a trifling proportion of grass-land, which is found beside the rivulets in the valleys, and is mostly mown for hay. The soil being but a few inches in depth, and often containing a large proportion of flints, naturally possesses very little fertility—often being a light sand, not strong enough naturally to grow turnips—so that the farmers were at first obliged to *make* a soil, and must now maintain its new-born productiveness. The three principal means by which this is done are the processes of chalking and boning, and manuring with sheep. A dressing of 80 or 100 cubic yards per acre of chalk is spread upon the land, and then a crop of barley is obtained, if possible, being sown with seeds for grazing. The seeds are grazed with sheep two years, the sheep being at the same time fed with oilcake; and then the land will be capable of producing a fine crop of oats. Bones are also used frequently for the barley crop, and when they first came into use were thrown upon the land in a chopped state, neither broken nor crushed, and as much as 40 or even 50 bushels per acre. The boning and sheep-feeding are in constant operation, but chalking is required only at intervals of a few years. On the western side of the Wold district, wherever the chalk adjoins the white or blue marl, an extensive application of it is made to the surface. Thus immense quantities of earth and stone have been added by manual labour and horse-carriage to the thin covering of original soil; and, besides this, the soil is being continually deepened by deep ploughing, the chalk fragments thus brought to the surface crumbling into mould. By these means is secured the existence of a soil of proper texture and capacity, and the land is then fertilized and its fecundity maintained by an incessant application of sheep-manure, farmyard-dung enriched with artificial food, and purchased manures of various kinds. The lowland farmer of rich land would be appalled at the prospect of laying out so much capital before a crop could be obtained; and feels a becoming respect for the intelligence and responsibility involved in the occupation and high management of a thousand-acre Wold farm.†

* As a corroboration of the above statement it may be mentioned that, at a public meeting held at Caistor a short time ago, there were present about 40 tenant farmers, to whom that town would be a convenient market, whose average occupation was 1100 or 1200 acres each.

† As a criterion of the scale on which business is conducted, it may be stated that the Withcall farm has three fixed steam-engines upon it, and the land is worked by no less than seventy regular horses.

The two crops upon which the success of chalk farming depends are turnips and seeds; the whole of the former and most part of the latter being consumed on the land by sheep. The corn crops are wheat, oats, and barley. The four-course system of management,—viz., 1. turnips; 2. barley; 3. seeds; 4. wheat—extensively prevails, but cannot be denominated the "Wold system," as over a great part of the district, and especially adjoining the heavier soil on the eastern slopes, the barley is found to have too strong a straw after turnips, thus injuring the young clover; and the farmers therefore practise a five-field course of,—1. turnips; 2. oats; 3. wheat; 4. seeds; 5. wheat: and particularly in the northern parts is an alternating four and five course rotation, the fifth course arising from grazing seeds two years; the two together forming a nine-course rotation. The variations from these general methods are many; among others, when the turnips have been early eaten off, the land is sown with 2. wheat, followed by 3. seeds, and 4. oats. Seeds are frequently broken up for barley or oats; and many farmers plough up their seeds when thin, and sow white mustard, this being fed off by sheep, their *treading* proving at that time more useful than the same treading on seeds.

The land for the turnip crop receives three ploughings on the stronger soils, but on the lighter parts only one ploughing, and then several scarifyings. There are no "lands" or "stetches" upon these hills; for, independently of the shallowness of the earth, the same dryness and porosity of the subjacent rock, which renders ditches here unnecessary, provides a downward passage for the rain without the aid of either slope or furrow. Accordingly, the teams often begin their work at one corner of a large field—(one field at Withcall exceeds 300 acres in area), and follow one another round it until by a spiral course they reach the centre. The turnips are sown on the flat; when ridged, the bulbs (being wider apart) grow large and coarse without yielding a greater weight per acre; the stock do not thrive so well on them, and they are additionally subject to turn rotten if the winter be severe. Ridging is practised in particular localities where there is a sufficient depth and firmness of soil, but the land is generally much too light for the purpose. The principal part of the farmyard manure is usually applied, we believe, to the root crop; but many farmers, particularly in the northern parts of the Wolds, manure the seeds also; and some apply *all* on the seeds—the virtues of the dung being supposed to remain in a dissolved state in the soil during the growth of the wheat crop, ready for forcing the succeeding turnips, which are sown early in the following season. This manure is made by beasts in the yards, fed on straw and oilcake; the average cost of the linseed-cake being certainly not

less than 20*s*. per acre, annually. The manure is sometimes laid on before ploughing, but generally afterwards; and at various rates up to 10 or 12 two-horse cartloads per acre. The seed is drilled in rows from 18 to 20 inches, or even 2 feet apart, and about 2 lbs. per acre. The universal practice is to drill crushed bones at the same time, in quantity from 8 to 16 or 20 bushels per acre. Besides this, a large amount of guano is used with the bone-dust, and superphosphate of lime, urate, rape-cake, pigeon-dung, and what is called in the central part of the Wolds "Louth manure," are very extensively applied to the land. Sometimes the above quantities of the bones are dissolved with sulphuric acid, but this does not seem to answer in some localities, as might have been expected. Nothing can be more useful where it is required as a temporary stimulant to the young plant; but it is thought that the raw bones are best adapted to the chalk lands, as they form, in crumbling, a portion of fertile and permanent soil as well as a proper nutriment for the roots to imbibe. Vast sums are annually expended in these manures, commonly about 20*s*. per acre: when the turnip land is not manured, more artificials are used, and there is one farmer (perhaps not the only one) who every year lays out 4*l*. per acre on his turnip crop in artificial manures. The most common varieties of turnip grown are the White Globe, White Stone, Purple Turnip (or Red Round), and Green-top Yellow (named also Yellow Bullock); but other sorts may also be found, though only a comparatively small quantity of Swedes. By high farming—*i e*. 10 or 12 loads of good manure and ash per acre, with 20 bushels of bones, either broken or dissolved—chalk soil, in many places not more than 3 inches in depth, will produce 20 or 25 tons per acre of turnips. An acre of good turnips is reckoned to winter from 8 to 10 sheep for 20 weeks. Rape is occasionally seen mingled with the turnips; but before drilling became customary it used to be frequently sown broadcast with turnips, and was much relished by the sheep, which (after dressing the grass from the hedges) invariably finished the coleseed before attacking the turnips. The roots are generally pulled, cleaned, and sliced—Gardner's cutter being universal throughout the district. A small quantity of turnips are sometimes drawn off for cattle in the straw-yards, the hedge-sides and valleys being fat enough to allow of this. Almost every farmer breeds his own sheep, and the general practice is to give the hogs (or tegs*) oilcake upon the turnips, and sell them to the lowland graziers in spring; and the drape-ewes (or crones) are fatted during the summer, and sold at Michaelmas. Many of

* A lamb eight or nine months old, and until his first shearing, is called a "heder" or "sheder" "hog," "hogget," or "lamb-hog." In other counties a "teg," "tog," "gimmer," and "dinmont," &c.

the flocks of breeding-ewes are very large, and it is not at all uncommon to find 1500 hoggets folded upon turnips in one field. The most general breed is a cross between the Lincoln and new Leicester sheep; but in the neighbourhood of Limber, &c., the pure Leicesters are found. Further north, the sheep are Lincolns crossed with Leicester rams, and may be termed strong Leicesters; and many flock-masters "finish" their sheep before selling. The Leicesters are usually turniped two winters, and sold fat from the turnips as two-shear wethers in the spring; they are sold to the butcher after being shorn twice, and but few are sent to the Wakefield market. Where this is done, of course a fewer number are bred.

It is pleasing to see the sheep, in their folds of netting and trays (or hurdles), eating their cut provender from troughs, and resting on a thoroughly dry layer; but on these hills, though exposed to the cold north-eastern blasts, there is an entire absence of the small stacks of straw and light sheds which seem indispensable on the wetter lowlands. The fields are so large, and the sheep in such great flocks, that it would be difficult to provide shelters of adequate size and number, and the animals would be found to lie under cover in rough weather instead of eating their food. If it were merely requisite to obtain the greatest weight of meat in proportion to the food consumed, of course this warmth would be in some degree a saving of turnips; but the aim of the Wold farmers being to make their land as solid as possible, it would not answer to house the animals, which by their treading prepare the land for a future crop of grain.

The seeds are generally drilled on the wheat and barley, or sown at the same time as the barley, and usually consist of one-third part red clover for mowing, and the rest trefoil and white clover mixed, or sometimes trefoil and rye-grass, for pasture. The clovers are mown once, and the eddishes grazed with weaned lambs: the mixed grasses are stocked with ewes and lambs during the early part of the season, and afterwards with ewes only, or, where the sheep are of the Leicester breed, with the shearling wethers also. Most farmers cake their hogs on the turnips, and many afford oilcake also upon the seeds: there can be no better method of improving poor land than grazing seeds with cake-fed sheep. Most of the grazed and mown seeds and clovers on the northern Wolds are again manured for wheat, the clover eddish being manured directly the hay has been carried: on that part which is left unmanured $1\frac{1}{2}$ cwt. of guano per acre is sown at the time of drilling wheat. The grazed seeds will be useful up to Christmas; but there is always a scarcity of "keeping" in the autumn. In hot dry summers considerable trouble is often felt in watering the stock. On the higher wolds, where there are no

springs, many artificial ponds exist,—being of a circular form, puddled with clay, and the clay faced with chalk-stones or flints to prevent the stock from treading and removing it; and wells are sunk to the depth of 90 or 100 yards. However, there are comparatively few table farms, most occupations being penetrated by gorges, in which the purest springs flow upon the surface, and the water, when necessary, is carried to the more elevated grounds in water-carts.

Much of the white corn is drilled, and dibbling is practised to some extent; but it is common to sow both oats and the wheat after turnips broadcast. The usual quantity of seed-wheat is 10 pecks, or in some places 3 or 4 bushels per acre, being entirely a matter of opinion. A great saving might be effected here; for it is certain that equally good crops have been repeatedly grown from a less amount of seed than is commonly sown.

Press drills are now often used immediately after the ploughs, in preference to the usual mode of drilling, some persons thinking that by pressing the crop will not be so likely to lose its root in February and March, and that the straw will grow stiffer, and consequently less liable to be laid in wet seasons.

All the corn is mown, but the barley left untied. The white wheats are most extensively grown, and the Wold wheat and barley are held by millers and maltsters to be equal in quality to those of any other county. The amount of produce is very variable, the yield from this fictitious soil necessarily depending upon the management under which it is placed. On an average of years the white yields as much as the red, and is worth more per quarter, "Hunter's White" and "Taunton White" being the most approved sorts. Whilst some farmers apply great quantities of manure, and even put on bones for the barley crop, others neglect this, and reap only a lean produce. The yield fluctuates from 2½ to 7 qrs. of wheat per acre; and the general opinion seems to fix the average of the whole district at about 4 qrs., seldom weighing less than 17 st. or more than 18 st. per coomb. Under high management, 7 or 8 qrs. per acre of barley, and oats of good weight 9 or 10 qrs. per acre, are frequently obtained. An intelligent practical farmer has estimated the average produce of a number of years over the central part of the Wolds as follows:—

	Qrs.	Bush.
Wheat	3	2
Barley	4	6
Oats	5	4

On the excellent soil in the neighbourhood of Barrow, and stretching between Barton and Grimsby, the general average is computed at rather above than under — Wheat, 4 qrs. per acre, barley, 6 qrs. per acre,—the quantity, like the quality, varying

according to the season, generally weighing from 14 to 16 stones per 4 bushels; oats, 9 qrs. per acre. Very few oats, however, are there grown for sale. The lands near the Humber often suffer from the dampness of the atmosphere; and the amount of produce is peculiarly dependent on the seasons. The higher the mode of farming the more variable is the yield. Six quarters per acre of wheat, weighing 18 stones the 4 bushels, have been grown, and on the same land in a humid season, with the same management, only 3 qrs. per acre, weighing 14 stones.

Generally speaking, the Wold lands never had a finer and more favourable wheat-growing season than the year of 1849, the crops being abundant, far beyond the usual average.

It has been mentioned that the operation of chalking recurs at certain intervals, and that an addition of soil is the result. The chalk also operates in various ways upon the land, and is now chiefly used to act mechanically, making the heavier soils work better, and giving solidity to the light loams; it prevents the disease in turnips called "fingers and toes," and is also found to kill the weeds. It is customary to cart 60 or 80, and sometimes more than 100, cubic yards per acre upon the seeds, the chalk being filled, carted, and emptied for 6*d.* per yard, the workmen finding horses. The filling alone costs 2½*d.* or 3*d.* per yard, according to the pit. The chalk lies until it gets enough frost to crumble it, and early in the spring is still further broken by an immense harrow (termed here "the devil"), and then sown with oats. There is no underdraining done except in some of the valleys, and midway on the dip of the hills, where the land is often wet with springs; and there is but little required.

The fences are generally neat along the whole line of the Wolds: in the southern parts many are planted upon raised banks, and have been plashed and laid; but they are usually short quicks, kept closely under the hook. There is very little wood upon the chalk hills, so that the farmers do not suffer much from the nuisance of hedge-row timber; there are, however, some extensive plantations, especially around Lord Yarborough's mansion at Brocklesby, and between that and Caistor.

Fifty years ago the average rental of the Wolds was 9*s.* per acre. At the present time it is probably 25*s.*, and over large areas the average is 28*s.* or 30*s.* per acre. Many thousands of acres have been improved from the value of 3*l.* and 10*l.* to that of 30*l.* per acre; and large tracts have been improved within a few years from 10*s.* to 30*s.* per acre rental,—facts which redound to the lasting credit and honour of the tenantry. In the parish of Limber four tenants became bankrupt while renting 4000 acres of land, for which they paid 2*s.* 6*d.* an acre, or 125*l.* each. The same land is now paying eight or nine times that amount of rent,

while the men who raised it to its present value have prospered in the process. There is a proverb that "slovens succeed once in about seven years;" and it is quite true that many farmers have been able to earn a living on the Wolds who deserve no better appellation; but the general district shows a pattern of good farming, and is adorned with numberless examples of clever management, clean cultivation, and the persevering application of manure.

There is no peculiar difficulty in cleaning the land. Couch ("twitch") is the greatest plague, and is worked out by dragging and harrowing, as on other light land. Poppies grow in wet seasons, and are injurious amongst the corn, being worst on the weakest land. The only sure method of eradication is to hoe the corn in the spring, and hand-weed it afterwards. The Wold farmers are not much troubled with wireworm. When the land has just been chalked, it is occasionally injurious to wheat, and sometimes to turnips; and a top-dressing of salt, mixed with quicklime, is then used to advantage.

The implements in general use may be denominated the best of their kind, the farmers having been liberal purchasers of recent inventions and improvements,—Crosskill's clodcrusher, Hornsby's drills, Garrett's horsehoe, the iron ploughs and harrows of Messrs. Ransome, Howard, Barrett, and Ashton; and other implements equally well known, are common throughout the district.

Some of the most celebrated farming is upon the estates of the Earl of Yarborough, where the land has been brought to the highest pitch of fertility, and every operation in tillage is completely and perfectly done; where whole fortunes are annually expended in the purchase of artificial food and manures; where the flocks and herds are not only large in number, but every animal is of superior breed and proportions; and where the farm-yards, buildings, and stacks are generally of suitable dimensions and neatness. All the improvements have been made, and fresh capital is being continually laid out, simply upon the guarantee of a good understanding between landlord and tenant. Very few leases are found on the Wolds; but the mutual confidence between the owners and occupiers has answered the purpose of leases, as far as the security of tenure is concerned, the names of the principal farmers being nearly the same now as in Arthur Young's time. There are many restrictions; but the agents have an increasing tendency to let the tenants do as they please with respect to cropping, generally allowing them to break their agreements. The soil possessing little fertility in itself, no farmer can exhaust and beggar it; he can only obtain crops in return for manure and management. Proprietors are beginning to under-

stand and act upon the truth, that a man may be a bad tenant and yet grow but little corn, or be a good tenant although raising a great breadth of corn. Where the restrictive system is fully carried out, if a piece of seeds or other crop miss, nothing else can be done with it except by asking special permission to break the course laid down in the agreement; but this order of things is rapidly wearing out, and the larger owners manifest a disposition to assist their tenantry in every reasonable way. "Tenant-right" seems to be a thing better understood in this county than in many others. The usual allowances to outgoing tenants for unexhausted improvements in North Lincolnshire are much as follows:—Bone-dust and guano are considered to last for 3 years; marl or chalk, 7 years; lime, 5 years; clay, on sandy land, 4 years, on some estates 7 years; draining with tiles 7 years, with sods or thorns 4 years. The allowances (determined by valuers) are calculated on a scale according to the proportionate time during which the tenant has received benefit from the improvement. Recently it has become customary to allow for oilcake given to the yard stock, on the assumption that the manure is improved to the extent of half the value of the cake consumed. The allowance extends over the last two years, and is two-sixths of the cake used in the last year, and one-sixth of that used in the previous one, making together the half of a year's consumption. Oilcake given to sheep in the field is excluded.

The next district consists of the *Heath* and *Cliff*, south and north of Lincoln, forming a range of light turnip soil, more than 40 miles in length. At the middle of the last century it was covered with heath, fern, and gorse, the only fences being the furze-capped walls of sand that enclosed the warrens; and Lincoln Heath was in such a wild and trackless state, that the tall, square column called Dunston Pillar (erected in 1751) was nightly illuminated as a beacon to travellers. In 1799, Young describes the enclosure as having taken place within twenty years. This refers to a large portion of the district which was thus improved from 0*s.* and 2*s.* or 3*s.* per acre to 8*s.* or 10*s.* rental, growing poor crops of barley and oats. Mr. Chaplin's large estate, formerly a succession of rabbit-warrens, let for 2*s.* 6*d.* per acre, was enclosed as lately as the year 1823, the rent being now about nine-fold what it was. The whole tract of Heath and Cliff has been brought into tillage, forming a pattern of high farming on inferior land, with hardly any instances of bad management. The present rental of Lincoln Heath averages about 30*s.* per acre, without tithes, which amount to an average of 6*s.* per acre, in most instances. The soil is all of the same nature, though some parts are rather heavier than others, the heavier land letting at from 25*s.* to 35*s.* per acre, and the light at

from 15*s.* to 25*s.*; but there are exceptions both above and below these amounts. As the land has little depth or natural strength, similar means to those employed on the Wolds are requisite to increase and maintain its fertility; and every farmer feeds off his turnips with sheep, buys oilcake to be consumed with his straw for manure, and applies large dressings of bones and other artificials to his land. The farms and fields on Lincoln Heath are probably on a much less extensive scale than those of the Wolds, but the standard of cultivation is very high, and, perhaps, in no respect inferior to that of the chalk district. Toward the southern extremity of the Heath land, in the neighbourhood of Grantham, a 6-field system of cropping is much practised, though it is now fast giving way to a 4-field course; the former being, 1st, turnips; 2nd, barley; 3rd, seeds; 4th, seeds; 5th, wheat; 6th, oats;—and the latter, 1st, turnips; 2nd, barley; 3rd, seeds; 4th, wheat—white and red clover alternately. In 12 years the former system gives—

2	crops of	turnips;
2	,,	barley;
4	,,	seeds;
2	,,	wheat;
2	,,	oats;

the latter—

3	crops of	turnips;
3	,,	barley;
3	,,	seeds;
3	,,	wheat.

By this it will be seen that the 4-field course gives as many white crops as the former in twelve years, an additional crop of turnips, or cleaning crop, and three instead of four crops of seeds. Travelling northward, through Ancaster, Temple Bruer, &c., the mode of management is in all cases the 4-field system, with a portion of the seeds usually mown; but a part of the turnip land is commonly sown with wheat. Oats are very seldom grown. The condition of the crops depends very much upon the season, a wet summer being always the best for the Heath farmer. From 3 to 5 qrs. of wheat, and from 4 to 6 qrs. of barley, are severally obtained. Last year the average yield of wheat over the northern and central parts of the district was about 32 bushels, and on some occupations 36 bushels per acre; but the general average of several years is probably not more than 28 to 30 bushels an acre. Barley is generally of good quality, weighing 56 lbs. per bushel; and the average of the whole district varies from 34 to 44 bushels per acre. About half the turnips are sown on ridges, bones being the principal manure. From 16 to 20 bushels were commonly put on; but during the last few years a much smaller quantity has been used, dissolved

with sulphuric acid. The usual dressing is 3 to 6 bushels of the dissolved bones, from 50 to 70 lbs. of the acid being allowed to the acre, and about 4 cartloads in some cases, or 8 or 10 in others, of yard manure. Many farmers, however, apply the chief bulk of their yard-manure to the barley stubbles for the benefit of the growing seeds and the following wheat crop. The oolite limestone soil is of a different nature to that upon the chalk, so that the raw bones, which are often most suitable for the latter, are not found to answer equally well on the former. A sufficient depth and firmness of soil has been already made, to allow of the bones being reserved entirely as a food for the plants. Various manures have been tried,—bones (dry and dissolved), soot, guano, rape-cake, salt, lime, pigeon-manure, urate, gypsum, fish-blubber, &c.; but the decision of universal practice is in favour of oil-cake yard manure, dissolved bones, and rape-cake. The latter is very much used for wheat, about 5 cwt. per acre.

There is no peculiarity in the mode of preparing the fallows for the root crop: the land is very easy to manage, as it may be worked in almost any weather. No lime or clay, we believe, is ever applied to the heath land. The turnips are generally the white varieties, with not more than one-fourth part swedes, the weight per acre being sometimes 30 tons and upwards. This is a breeding district for sheep, and a fine cross between the Leicesters and Lincolns has been long established. Lambs are, however, very commonly brought to the turnips; and the mode of feeding and time for marketing are similar to those on the Wolds. The cattle are generally of the improved short-horn breed, some of the best of which are bred at Wellbourn; but the usual system is to buy beasts in the autumn for the yards, and through the winter they are fed on straw, and supplied with from 3 to 6 lbs. of linseed-cake each per day.

There is no grass land upon the Heath; every part of it (with the exception of a few woodlands) is under culture, abounding with spacious well-constructed farm-buildings, strong well-fed working-horses, and immense folds of sheep: the barren sheep-walk and warren have been clothed in fruitfulness, and their richness preserved by unremitting and unstinted weeding and manuring. No underdraining is required, except in the valleys of the southern part of the district; the surface between Sleaford and Lincoln being rather flat, with a gentle slope eastward from the escarpment, the surface-water passes too freely away through the rock. The soluble components of manure are here liable to be lost, and the land subject to be dried and parched by the sun, though in winter the sandy soil makes a dry and admirable layer for the sheep. As a peculiarity in the working of the land, we believe that, in sowing wheat after clover, the land after being

ploughed is first well harrowed, the seed is drilled, then covered in by harrows, and the ground then rolled and harrowed again after the roller.

The subsoil plough has been found beneficial upon the Heath; as it brings up the broken calcareous rock, at once deepening and manuring the soil.

The fences consist of neat thriving quicks, kept trimmed about 4½ feet in height; those next to the roads are generally lofty and substantial stone walls.

On the Cliff, which extends from Lincoln to beyond Kirton, the best and most common rotation is the 4-field; with some farmers the four and five courses alternately,—both plans being subject to many deviations. Ridge culture is practised where the soil is sufficiently deep; and great quantities of bones and bone-dust, guano, ashes, nightsoil, and various composts are used with the turnip crop. The chief sorts grown are the tankard, or sugar-loaf, for early feeding; the white stone, for about Candlemas; and the green top yellow for spring. Swedes are but little grown, although many farmers are beginning to cultivate them, and with great success. The sheep are of a large breed—similar to those on the Heath, and are all bred in this district. The hoggets eat the turnips, ("heders" first and "sheders" next,) followed by older sheep, drape ewes, &c., to clean up the "hulls" or shells. In summer the ewes and lambs are on the grass land, and the wether lambs are weaned on the clover, the "heder" hogs being grazed on the seeds, and the "sheders" on grass. The grass is not feeding-land, and there is very little on the Cliff-hill, from Brigg to Lincoln. One consequence of this absence of all pasture or good grass is, that in this district less horned cattle are bred than in almost any other. The beasts kept are but few; generally a few 2 years and 2½ years old steers, bought in to graze on the pasture land during the summer; and then these, together with as many more bought in as are needful, are caked with straw in the yards and sold out in the spring. They are usually a cross between the old Lincoln and Improved Short-horn breeds.

It is customary to lay down only half of the seed land for grazing, generally consisting of white clover and ryegrass mixed; and the rest is sown with red clover for mowing. The seeds are commonly grazed two years; thus making a 5-field course on part of the farm. The average yield per acre of the corn crops, considering the proportion which the good and useful land bears to the inferior, is about 28 bushels of wheat, and 40 bushels of barley. This district has been reclaimed from its condition of moor and warren in a similar manner, and at a corresponding period, to the Heath; and the rent may now be stated at 30*s.* an

acre. The fences are well-kept quick hedges and stone walls. A peculiarity of the Cliff, as opposed to the Heath district, is, that a considerable extent of land is sufficiently wet to require underdraining, owing doubtless to the greater depth and tenacity of a great deal of the soil. Between Kirton and Lincoln are several extensive plantations; but this broad tract of gently sloping land is generally bare of wood. The Brigg and Lincoln turnpike passes through the midst of it, for 17 miles, in a straight line, having the lighter arable land upon each side; and most of the surface is well farmed, the system of management presenting as little diversity or digression from a certain line as the road itself does, though the practical application and results of that system vary much, according to the skill and enterprise of the occupiers.

No comparison between the farming of the oolite and chalk ranges is here attempted. The facts that have been collated are given without the slightest aim of lauding the cultivators of one district at the expense of those in another, and readers are left to form their own estimate of the respective merits pertaining to each; of course, comparing the modes of husbandry with the nature of the soils, as described in the first division of this Report. It may also be remarked here, that if this account of Lincolnshire farm-practice appears to be devoid of any brilliant examples of particular estates, and deficient in extraordinary instances of cattle-feeding, and minute descriptions of superb farm-buildings or other uncommon objects, it is because the author wishes, if possible, to exhibit, in a necessarily small compass, an outline of Lincolnshire management, as it is most generally and commonly pursued.

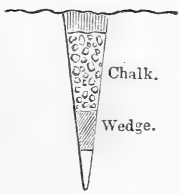
Between the Wolds and the sea-shore is a broad band of heavy soil, that portion next the sea being a rich tract of marsh, and that next the hills an extent of undulating country, named the "Clays." It is proposed to notice the *Clays* and *Marsh* as a single district, and to survey separately the methods of farming in different localities.

Between Barton and Grimsby the clay land adjoins the Humber; and lying between it and the chalk is a considerable stretch of land, varying in its nature, but chiefly a mixed soil, partaking of the qualities of both wold land and clay, and forming a very good and productive soil, except where the clay is very decided. Unlike the Wolds, although so near, it is chiefly in the hands of freeholders, and the management consequently is very various. Potatoes, beans, wheat, and turnips are grown: sometimes the land is summer-tilled, in other places two white crops are occasionally taken together. The general management is decidedly inferior to that of the Wold land. The produce is usually good.

This soil grows very fine red clover for mowing, a small proportion being needed for summer-grazing. There is only a small extent of pasture, tillage having been hitherto considered the most profitable. Underdraining is practised where it is found to be necessary.

On the clay land the principal area is under grass, the greater part of which is in meadow. The arable portion has been very much improved by underdraining where the condition of the open drains rendered it practicable; but considerable advantages have yet to be gained in this respect. The yield of wheat on this land is generally above 4 quarters per acre; the produce from spring corn depends mainly on the management. No regular system is pursued in the rotation of cropping, but potatoes and beans are the most productive crops. The farm management exists in all gradations of excellence from what is termed high farming to the most slovenly and dispirited.

That part of the clay district below the Wolds, from Humberston north to Louth south, west of the Louth navigation, has about three-fourths of its surface in tillage. It is usually cultivated on the 4-field system, though with numerous variations, and is decidedly a breeding district for sheep. The rent averages from 28*s.* to 30*s.* per acre. A considerable extent of liming is practised, particularly on those farms which lie near to the chalk. Underdraining is done with sods or wedges of earth, but few tiles or pipes being used. The drains are generally 30 inches deep, of the form represented in the accompanying diagram, the space above the wedge being filled up with chalk stones in order to make a porous covering to the drains. Drains of this kind have lasted upwards of 24 years, the sod not being found to moulder, but merely turning greasy with the wet. They are placed at intervals of $3\frac{1}{2}$ yards in some instances (the chalk of course being used only on lands which lie near to the Wold hills), and their beneficial effects in diminishing the adhesiveness of the soil and removing its coldness and wetness are very great.



Between Humberston and Saltfleet is a belt of marsh, having an average breadth of 4 to 5 miles. It chiefly consists of grassland; and, formerly, every bordering wold farmer used to have a piece of marsh, "shepherded" for 1*s.* an acre. It is now partially a breeding, but more a feeding district: about one-half is good feeding land, though not so rich and powerful as the grazing lands near Boston. It carries from 6 to 8 hogs per acre, or a cow an acre, the sheep going away at a weight of about 30 lbs. per quarter. About one-fourth is meadow (*i. e.*, mown for hay) and breeding land, and the remaining fourth is arable, consisting of

the inferior grass lately broken up. It forms an excellent corn soil, but the system of cropping is very various and irregular. When freshly ploughed up the first crop is sometimes wheat and then seeds, but as often the first crop is oats, followed by a second crop self-sown; generally speaking, beans come after wheat, and a dead-fallow before it. Coleseed or rape is occasionally grown on the best marsh lands, but the clay is very shy at producing green vegetables—it lacks the carbon and humus of the peat fens. A few potatoes are cultivated, but no woad or other uncommon crop. Improvements have been made by the application of lime, and also by the use of artificial manures, bones and linseed oil-cake being more generally purchased than anything else of the kind. A more extended adoption of the frequent-drain system is much required: the open drains are sufficiently good to allow hollow drains of a moderate depth to be laid; and from what has been already effected there is every encouragement to proceed with the improvement.

A singularity deserving to be mentioned is the existence of a rabbit-warren in this district; it is situated at Saltfleet, on the sandy margin of the sea.

The average rental of this portion of the marsh district may be stated at from 40*s*. to 45*s*. and 50*s*. It was remarked that on the Wolds restrictions as to cropping were being broken through; but here the case is otherwise. Upon the hills the tenants are finding out that, as they can get nothing from the soil except in return for what they put in, to be bound down to certain crops is at once to limit their enterprise and profit: here, on the other hand, the proprietors are interested in preserving the natural fertility of their soil, and imagine that by holding the tenants to a certain number of grain crops, a fixed course of management, or other burdensome restrictions, they are guarding their land from deterioration, in all probability forgetting that hindrances of this kind are bars to industry, and that it is not by the prevention of growth on their land, but by the investment in it of the farmer's capital, and by his remunerative management of it, that their property is made to retain its productive powers.

Coming southward to Alford, &c., the same relative position of the soils is maintained, the heavy land between the marshes and the wolds assuming the name of the Middle Marsh. Like the same soil further north, immense tracts of it have been broken up, and during the last 20 years many thousands of acres of rich maiden earth have been brought under the plough. About one-third of the Middle Marsh and half of the Marsh probably remain under the sward. Along this low land, and further south upon the edge of the Fens, the occupations are much smaller than upon the hills, being principally in the hands of small free-

holders farming their own land of 5, 10, 50, or 100 acres. Being thus subject to no rule, these cultivators have not confined themselves to any regular course of cropping; but it is now becoming general to sow half the land with wheat, having root and pulse crops intervening. On the loamy marsh soil it is common to have turnips or coleseed followed by oats, wheat, and then beans,—occasionally seeds and wheat. The coleseed is never grown for seed, only for eating off, and is generally mingled with turnips; the proportion is small, not more than one-fourth of the fallow land being sown with it. Occasionally a proportion of the turnip crop is left for seed. Scarcely any swedes are found here. On the clay land very few roots are grown, and those few are carted from the fields, as it is impossible to feed them off. Tares, or vetches, are frequently sown; and likewise white mustard for ploughing in or feeding, as it is an excellent forage for sheep. The usual mode, however, is to summer-fallow for wheat, which is often sown broadcast and ploughed in; then come beans, and sometimes wheat again. This mode of culture is a great improvement upon that mentioned by Young: bean land was wretchedly managed; he says,—"as a general fact it is to be stated, that this crop is broadcast, never hoed, full of weeds, and wheat consequently not following it. In the wet open fields, fallow usually succeeds." At that time, too, drilling white corn was being tried, and after various experiments by many farmers abandoned. "Were all the men known who have tried this husbandry and laid it aside, the advocates remaining would not figure by their number." Neither woad, chicory, red mustard, flax, nor other officinal or manufacturing plants are cultivated in the north marshes; and even barley is but seldom grown. The average produce is about 4 or 5 quarters of wheat, oats 6, 8, or 10 quarters, and beans very much according to the season, probably from 3 to 6 quarters.

Until the last two years very little underdraining had been done in the Marshes, but it is now becoming general, the favourite method being that of pipe-tiles. On the Middle Marsh a considerable extent has been effected with chalk stones, especially at the foot of the chalk-hills, where the material is close at hand. The chalk is broken and placed in drains 3 feet in depth, and, when filled to a certain height, covered with the soil; the outfalls being constructed of tiles, as otherwise the stones would be crumbled (and the drain thus injured) by frost. The drains are generally laid along every furrow. On this part of the district considerable quantities of lime have been applied to the land with very beneficial effects. A large proportion of grass in the Marsh is mown for hay, which is produced in great bulk; but, whether from its abundance or not, little pains are bestowed upon

"making" it. The swarths have been known to lie for weeks unturned, and the ricks are often left unthatched. There are no large towns in the neighbourhood to make the hay valuable, and it is produced in such plenty, that the farmers do not bestow that care and labour upon it which characterise the hay-making in Middlesex, and scarcely ever shake out the grass the same day as mown. The sheep in this district are all of the Lincolnshire longwool breed, the beasts are shorthorns. The average rental per acre is from 30*s.* to 35*s.*, but sometimes 60*s.* or even 80*s.* per acre are given.

The Marshes are chiefly used as a feeding district for sheep, as from the unsuitableness of the herbage to lambs, and the entire absence of hedge-rows or shelter of any kind, breeding cannot be carried on with success, and the water in the ditches being frequently brack is exceedingly dangerous to young cattle. On the Middle marsh are some extensive woodlands and fences of whitethorn, and a pasture better adapted for breeding purposes; consequently, a few beasts and many sheep are there bred and fattened on the grass lands.

Approaching the Fen-land, the clay-land becomes narrower, and the Marshes extend towards Wainfleet in a tract of remarkably rich grazing-land. On the Middle marsh the proportion of grass is less; and owing to the extended practice of under-draining, a considerable breadth of turnips are being grown. Dead fallows were almost universal a few years ago, but by the action of the rain-water and the atmosphere upon the drained soil the principal part is now capable of being fallowed with a crop of turnips, swedes being grown on the stronger land, and white turnips on the loamy and lighter soils. The proportion of dead fallow has been much reduced by good sub-soil-drainage; but why stop there? Great difficulty is yet experienced in the consumption of the turnips, the land is heavy and very tenacious, horses injure it by the weight of their footsteps, and whatever may be the season it is generally either too wet or too dry to work easily: why, then, should not the stirring of the solid and cohesive sub-soil follow the laying of hollow-drains beneath it, and thus secure a thorough drying and lightening of the land? Two objections have been adduced; the land is already soft enough in wet weather, and allows the horses to sink in, and those who have tried sub-soil ploughing have gradually relinquished it. Now it is well known that both the softness and hardness of clay arise from the moisture within it, the first from its wetness and the latter from the sudden drying of it when wet. It is the presence of too much water that renders clay-land sticky and soft, and makes it set when drying; but remove this cause of mischief, and the soil will remain generally in a loose and friable state, never so hard

as to hinder tillage, and never too light and greasy to bear the tread of a horse. And there cannot be a more reasonable way of effecting this than by providing, with a proper implement, a passage downward through that pan of earth which the rain-drops have hitherto been unable thoroughly to pierce and disintegrate. The second objection has little weight; for if a few individuals give up a good practice out of alarm at its cost, that is no reason why others, who are convinced that the lasting amelioration of a piece of clay-land amply repays for ploughing every few years once down every furrow, should not adopt and persevere in it.

No general system of husbandry is practised in this part of the district under consideration, a common practice being to crop as long as the land will bear it. A 5-field course is found very suitable, viz., 1. turnips; 2. oats; 3. wheat; 4. clover; 5. wheat. Clover is produced in great abundance: the practice of growing it being new, the soil is rich for it. Beans and clover are both extensively grown, and form two of the best preparations for wheat that are to be found. A small breadth of mangold-wurzel is grown, but no coleseed; and there are but few crops of potatoes. Liming has been done to some extent. The sheep and beasts here are all bred in the district.

The next district coming under notice is that stretching between the chalk hills east, the cliff range west, the Fens south, and the town of Brigg north; and includes the broad tract of drift clay, the narrow reach of Kimmeridge clay, and the green sand formation which, though running parallel with the chalk from near Brigg to its southern extremity, is of too small an area to merit a separate division of this Report. It is proposed to consider both sand and clay conjointly under the name of the "*Central District*." The red clay belonging to the green-sand formation is, in the neighbourhood of Spilsby, good corn land,—it works easily and yields well. The following is found to be an excellent course of cropping for this kind of soil:—1. turnips; 2. wheat; 3. barley; 4. turnips; 5. oats; 6. wheat; 7. clover; 8. oats or wheat. But the most usual rotation is—1. turnips; 2. wheat; 3. barley; 4. turnips; 5. barley; 6. seeds,—if white clover, grazed two years and manured, or mown one year and manured,—then broken up for oats or wheat. Under the best management the seeds are manured both years when grazed; a practice which answers well, particularly on the sandy soil, the porosity of which is such that the strength of the manure soaks very quickly away. It is better to lay on 7 loads per acre frequently than a heavy dressing all at once at longer intervals. The practice of top-dressing the clover certainly incurs a waste by evaporation; but the loss by soakage would occasion great injury to the crops growing two or three years after the appli-

cation of the manure, if the other plan were followed,—and as it is, the waste is rendered as little as may be by choosing damp weather for the operation, so that the salts and ammonia are washed into the soil. The mown seēds are generally a mixture of rye-grass and clover, the Timothy, or cats'-tail grass, not being grown. Clover is an excellent preparation for wheat on some soils; but here the wheat after it is liable to lose plant. On the sandy land the common course is—1. turnips; 2. oats; 3. wheat; and then either turnips again or clover. The Norfolk 4-course shift is not generally but still frequently pursued, no regular system being adopted by all the farmers. White turnips are the chief sort, though many swedes are grown, and all the roots are cut and given to the sheep on the land. The sheep are generally supplied with oil-cake, and great care is taken to feed them (with both cake and turnips) regularly and at the proper rate. Hardly any coleseed is grown. Tares are often sown for feeding with sheep, being ploughed up in July and the land sown with turnips. Turnips and cabbages are the principal green crops, the mode of cultivating the latter vegetable being very simple,—the land is ridged with manure just as for turnips, and then the plants are set by spade: the cabbages fill the place of turnips in the rotation. Thus the farmers here have demonstrated by extensive practice what chemistry proves by analysis, viz., the superior nutritive qualities of this useful plant as compared with most others. Very little pulse-corn is grown upon these hills, and the varieties of wheat commonly sown consist of more red than white. Wheat is dressed for "smut" in various ways, sulphate of copper being commonly used: it is usually drilled in rows 7 to 9 inches apart, the quantity of seed being 8, 9, to 10 pecks per acre. The produce of most of the sand district is about 3 or 4 quarters per acre. The working of the land presents few peculiarities, very little scarifying or skeleton-ploughing of the surface being customary; nor is there any particular disadvantage felt by young cropping, the obnoxious wire-worm not making any grievous ravages. The weeds are very troublesome, especially the wild oat, butter-cup, and "needle," —of course, in addition to that pest of husbandry upon all soils, the "twitch," or couch. All the grain crops are mown and tied. About one-third of the land on this formation is in pasture, which is grazed by the breeding cattle, or "holding stock," during the summer, the seeds being at the same time stocked with sheep. Very few bullocks are fattened upon the hills; many farmers winter twice as many beasts as they can summer, buying them in autumn, keeping them in the yards on straw and cake, and then selling them in spring to the grazier. This is not at all a dairying county; but every farmer keeps from 2 to 4 cows—

enough to supply his own household with dairy produce, and furnish a few pounds of butter weekly for the market. The cows are fed in yards during the winter on cut "meat," that is straw and clover, usually cut an inch or an inch and a half long.

The proprietors are not generally large owners; and all the tenant-farmers are tenants-at-will. Some holdings amount to 1000 and 1300 acres each, but there are a great many 60 and 80 acre farms, the average size being about 200 acres throughout the hill district in front of the chalk. All the parishes near to the Fens are tithe-free: they possess allotments of fen land, the tithes being compounded in the following manner:—When the three fens named East, West, and Wildmore, were drained,—of the total quantity of 40,009 acres the Duchy Court of Lancaster took one-twentieth part as a compensation for manorial rights, and the remainder was divided into parochial allotments amongst the towns claiming right of common. Acts of parliament were subsequently passed for the inclosure of the fen allotments, and the waste lands within these parishes; and after a certain portion was decreed to the impropriators in lieu of tithes, the rest was awarded to the proprietors of toftsteads and lands within the respective parishes.

In the townships north of these the tithe still continues an annual burden of 5*s*., 6*s*., or 7*s*. per acre.

The general surface of the hills which run several miles northward from Keal is much more wooded than that of the Wolds, and there are several extensive woods and fox-covers. The fences are generally neat quicks; in many places upon banks; small grips or ditches being dug, the earth laid all on one side, and the quick planted on the bank thus raised. But this is an injudicious plan, the soil falling away from the stems and roots on each side, and by this exposure damaging the growth of the hedge. The whole tract was anciently covered with gorse and ling, having cultivated spots and pastures round the villages—it now has the aspect of thriving crops and luxuriant herbage in almost every part, being generally highly cultivated. The rent probably averages about 30*s*. per acre.

The improvements which have taken place upon the sand and red clay soils are well worthy of attention, and mainly consist of underdraining, marling, and liming. The drains are constructed with a view of cutting off the springs upon sloping land; very few stones are employed for the purpose, the tile and sole being most usual. The drains are invariably deep, and the practice of this great point of good husbandry is universal throughout the district. Arthur Young states that at the period of his survey the wetness of the hill-sides about Mavis Enderby, Bolingbroke, &c., was lamentable, and that "he was a desperate fox-hunter, who

ventured to ride there without being well acquainted with the ground." It still remains a fact that many of the steeper declivities under pasture possess boggy spots overgrown with rough grass and rushes, and the draining-tool might here prove of great service; but the general drainage must be considered as remarkably improved by the great numbers of tiles that have been laid within a few years.

Fifty years ago the farmers had begun to make use of the white clay (or chalk drift), which is found on hill-tops in the neighbourhood, and of the blue marl which lies in their valleys, to alter and improve the nature of their red sand and clay. The practice has largely increased since that time, and many estates have derived a permanent advantage from it. The white buttery marl gives both strength and solidity to the soil; and a farmer having applied it to only 2 lands in one of his fields, found that the yield of corn from those lands was fully 2 or 3 coombs per acre greater than from the remainder of the field. The marl is also found to prevent the "clubbing" of turnips (or the disease called "fingers and toes"), to which this land was subject. The blue marl is beneficial, but in a minor degree. It is common to put on 40 loads per acre; and one dressing of the white clay is found to be amply sufficient for a great many years, it being questionable whether a second application on the red land is calculated to be useful. Some of the most intelligent managers in the district recommend once marling with the white clay, then when the land again grows weak apply 5 chaldrons per acre of lime; in a few years after that lay on a dressing of the blue marl. Marling, however, is a great expense, and therefore not nearly so many farmers have adopted it as should have done: considerable improvements remain to be effected in this respect. The practice of liming is very general; indeed the principal manures used are lime, and farm-yard dung enriched with linseed food; bones do not succeed well upon the red-clay soil. The lime, which lightens the clay lands in the Middle-marsh, gives solidity to these light soils, and also facilitates the decomposition of vegetable substances into fertilizing ingredients. In order to accomplish the latter and other uses in the land it is necessary that the lime should be applied in a quick state. Accordingly it is fetched from the chalk hills (generally several miles distant), and "hilled" for 2 or 3 weeks before used, the heap being covered over with earth. In the process of making the heap, the outside portions "fall" by the absorption of moisture and carbonic acid from the atmosphere, forming a protective shield above the remainder, and, with the assistance of the added covering of soil, preserving the bulk for a long time free from the action of the air. About 5 chaldrons (varying from 4 to 7) per acre is a pro-

per dose, and is thrown hot from the carts upon the fallows. At this rate it is advisable to lime once in 8 years; but when only 3 chaldrons per acre are applied the dressing must of course be repeated more frequently.

If any further improvements may be suggested, perhaps the main requisite is the use of the sub-soil plough on the red clay; there is generally a bed of very stiff soil, often hardening into a stony substance called "iron-mould," beneath the surface tilth, which appears to need the pulverizing action of the deep share to improve both the texture and temperature of the soil.

On the white clay, between Hareby and Horncastle, about one-third is in grass, and beyond that, by Wragby, &c., about two-fifths, and in some parishes one-half. The sheep are crosses between the Leicester and Lincoln breeds, and the beasts are generally improved short-horns. The usual course of cropping is a four-field system, but owing to the badnes of the layer dead-fallows are unavoidable over a great part of this district. Wheat of course is the first crop after a dead fallow, succeeded by red clover. The land is partly ridged for the green crops, which consist of both turnips and coleseed, and mangolds and cabbages in small quantities. The turnips are followed by barley, and the red clover is succeeded by beans, peas, or oats, and barley on the turnip-land, the aim being to avoid two white straw crops together. The usual varieties of wheat are red—"Spalding's-red," a coarse heavy kind of wheat being commonly grown. The average yield of such wheats upon this kind of land, including the clay with gravelly sub-soil, is about 3½ quarters per acre. All the grain crops are mown. In many parts of the country, especially on the light sandy lands where furrows are few, no care is bestowed upon making the drill-rows straight by the furrows, the aim being merely to keep them equidistant, without paying much attention to bends in their line of direction. On the Hareby estate (and perhaps also on various others) the "lands" on the white clay are ploughed about 8 feet in width, and the drill is wide enough to cover all the land between furrow and furrow. By means of this arrangement there is no irregularity in the rows, all being at equal distances, and the crop shows no defect on the ridges (or middle of the stetches). The commoner method on heavy land, particularly in the alluvial districts, is to have the furrows 12 feet apart, with a drill to fit half the distance; and it requires an experienced drillman to work the "swing" mechanism connected with this kind of drill in such a way as not to run the ridge rows into one another, or swerve them too far asunder. In either case the furrows must be exactly parallel, and at precisely the right measure apart that fits the drill: if trampling is injurious the horses can also be made, in both cases, to walk down the

furrows only. The latter plan, however, has one advantage over the former, even if the requirement of one or two horses less to work the drill be taken for nothing, viz., that there are one-third fewer furrows in a field, and these being lowest, are generally found to be the most failing places.

There is a considerable extent of woodland upon the drift hills, and the fences, though generally neat, are not all trimmed by the hook, many being allowed to grow up bushy for the purpose of making long faggots or kids.

Some beautiful farm premises are found on the larger farms in the central district, but good buildings, though great improvements have been made within 20 years, are, notwithstanding, very rare; and both on the white clay and green-sand hills, the homesteads are usually ill-arranged, badly constructed, and the barns and sheds inadequately proportioned to the size of the farms and the head of stock. A common mode of building hovels, barns, &c., on a small scale, is to fix up a framework of wood, and cover it with plaster. This plaster is the white marl mixed with water, having straw well chopped up amongst it; and, after standing a week before used, makes a hard and cheap walling for light buildings. This style of architecture is called "mud and stud," and formerly the cottages of the poor were universally erected after the same rude and miserable model.

There are a few leases in this district. The average rent per acre of the clay is about 24*s.* to 26*s.*, subject, in many cases, to the tithes being paid by the tenants.

Most farmers marl their own land if they have pits of either white or blue clay upon their farms; but where the sub-soil entirely consists of gravel or sandy clay, this means of fertility is beyond their reach, or cannot be obtained without incurring too heavy an expense.

The best and greatest improvement on this clay has been that of under-drainage. It was commenced about 30 years ago with horseshoe tiles and "bats," or soles, which were laid at only 16 inches depth. At the present time, however, scarcely any shallow draining is done, the tiles never being put in at less than 3 feet from the surface; and nearly all that was done during the first 20 years has been taken up, and the land re-drained at the above and even much greater depths, it being found that with the shallow system the land was always wet. By this means the whole country in the neighbourhood of Wragby has been greatly dried and improved, and the difficulty which attached to the various operations of husbandry gradually weakened and reduced. But it is on those lands which rest on a white clay sub-soil that draining has given rise to the most striking improvement; the process of claying (as practised in the fens) being here combined

with hollow-draining in one manual operation. The drains are cut to the depth of 3 feet 6 inches, or 4 feet, and made 12 inches wide at the bottom in order to get a large quantity of the white marl to throw out upon the surface of the land. The clay from these trenches is spread over the field, and when it has become thoroughly incorporated with the soil, which is not the case during the first season after its application, a very considerable increase of productiveness is the result, accompanied by an alteration of the land that renders it easy to be kept clean.

That portion of the central district which lies near the Fens, and stretches between the Witham and the neighbourhood of Wragby, was anciently a tract of woodland and sandy waste. There are still extensive woods in the parishes of Revesby, Mareham, Tumby, &c., remains of the ancient forest named "Tumby Chace;" and also in Bardney, Stainfield, Barlings, and many other parishes.

North of Tattershall is a wide sterile tract called Tower Moor, which was divided among the surrounding parishes about 90 years ago. A part of the moor allotments has been inclosed and reduced to cultivation; but much remains open in its wildness and desolation of heath and ling. Beneath the light sand and gravel, at a considerable depth, generally about 12 feet, is the Oxford clay, forming a valuable bed for admixture with the peaty sand on the surface. The expense of excavating it is doubtless the main drawback to an extended use of it upon the moor. On the portions cultivated the usual system of cropping is, 1. turnips, 2. barley or oats, 3. seeds, 4. wheat.

Northward of Market Rasen, through Holton-le-Moor, and between Caistor and Kelsey, is a tract of light sand which formed large rabbit warrens until a few years ago; the banks of sand-sods and the furze-fencing, which crowns them, still testifying of its late condition and predatory occupants. Some parts of it have been brought under turnip culture, but large tracts are completely sterile and bare, whilst other portions have been covered with plantations, viz., of thriving Scotch firs and larches amongst a thick underwood of gorse. A square of it belonging to Caistor, Nettleton, Clixby, Searby, Grasby, Kelsey, &c., was viewed by Young at the close of last century; and he states that these moory commons were reported to him to be so bad as not to be worth cultivating, "but on examining them I found them miserably pared for fuel; the moor is not good, but would pay well for inclosing and cultivating." By the powers of an act passed in 1798 the inclosure took place; and the long lines of plantation are now fenced from fields arable and pasture, and from straight and good roads, by neat and well-grown quicks. As this tract is low and level, and by numerous water-courses transmits

to the Ancholme river the flow of innumerable springs violently thrown out by the clay stratum of the hills, many parts of its surface are wet, and demand considerable pains and cost to secure a good drainage. Underdraining in such a loose running soil as this is no easy task; the best kind of drain is found to be that made by common tiles and flats, the ends of the tiles being held "flush" with each other, so as to prevent the ingress of the sand. The main difficulty attendant on the efforts of the drainer here is the slow but inevitable choking of the drains by an irony incrustation; this generally occurs in the period of almost 6 or 7 years, and new lines of drains are then laid down, it being not worth the time and labour to take up and cleanse out the old ones.

Both chalk and white marl are productive of beneficial results when applied to the sand, but the principal material used for admixture is the blue clay, which, forming a ridge of low hills west of this tract, is found beneath the sand at various depths, and nearest to the surface in the western portions. It is spread upon the land and mingled by harrowing, at the rate of 100 cubic yards per acre. At pits of it, near Caistor, the clay is sold at 8*d*. per yard, costing the purchasers also 2*d*. per yard to dig and fill.

Turnips, barley and seeds are the chief crops, but if there be any regular course pursued it is most commonly the 4 or 9 course, as on the Wolds. The turnips are always eaten off by sheep; and it is usual to make the land solid after it has been sown with grain by the treading of a flock of sheep. Much of it is pressed, but more is trodden in this manner. As it is but a poor soil the produce is proportionably scanty, the average yield per acre of a number of years being estimated at 2 quarters 6 bushels of wheat, and 3 quarters 6 bushels of barley; though of course much heavier crops than these are often obtained. The sand is peculiarly infested with willow weed.

On the clay land, west of this flat, is a long but narrow line of good pasture land stretching through Owersby, Kelsey, &c., towards Brigg; and on the east is a tract of grass on the red clay which caps the lofty sandstone hills from Claxby to Nettleton, and stretches also north of Caistor, through Grasby and other villages. But the quantity, when compared with the arable land, is small, the proportions in this neighbourhood being estimated at eight-tenths in tillage and two-tenths in grass. The larger sheep are made fat upon the richest land, which is to be found of the best quality here and there; and the Leicesters are "turniped" during two winters. The usual course of cropping on the clay is a four course, viz., 1. fallow, without a crop; 2. wheat; 3. seeds and red clover alternately; 4. beans, peas, or oats, or sometimes wheat again. Swedes are occasionally grown on the clay and

also on the sand, being drawn off the land in the first case and consumed by sheep in the latter. A considerable proportion of land in the vicinity of Caistor still requires to be underdrained. The average yield per acre on the clay is computed at 3 qrs. 2 bls. of wheat; 2 qrs. 4 bls. of beans; 5 qrs. 4 bls. of oats; and 2 qrs. 4 bls. of peas; thus showing the native poverty of the soil as well as a deficiency in many instances of first-class management. An improvement which might be more generally adopted is the application of the neighbouring sand to the heavy and stubborn clay. This has been tried with success, and a mutual exchange of poor materials might thus be made to effect the enrichment of each; the transported infertile clay becoming the source of productiveness to the sand, and the dry loose sand, when carried to and mixed with the clay, mitigating its harshness, and rendering it mild and prolific.

The *Carrs,* or low grounds on each side the river Ancholme, lying between the land last noticed and the oolite hills, in a narrow tract from Bishop Bridge to Ferraby, come next in the order of survey chosen in this Report. The principal breadth being north of Brigg, the following remarks are chiefly applicable to that part of the district. About half the area is in pasture, which differs much in quality. The best is good enough to feed heifers; but the grass is not generally feeding-land, its chief merit being its excellence for growing stock. There is a tract of land, chiefly under grass, between the Wolds and the lowest or middle part of the flat, not of very good quality, and this has been underdrained. Underdraining, however, is rarely practised in this level. Most of the arable land has been broken up at a comparatively recent period, and the work of converting into tillage is still progressing. The turf is first pared and burned, and then the land is ploughed; two or three white crops being taken in succession. On the deep alluvial soil, or warp, next the Humber, the principal crops are rape, oats, and wheat; a few turnips are grown, but no beans,—and the land when first taken up from grass is generally sown with rape and wheat. The stripe of peat below Saxby, clothed with rushy herbage, has been partly underdrained, and forms when the water is removed from its mass a very light and spongy soil. Clay from beneath the black land westward of it has been applied to it in some instances, and good potatoes grown. The carr land in the neighbourhood of Ferraby and Saxby requires the application of lime, and the admixture of the sub-soil with the surface tilth could not fail to be productive of benefit. Bones are never employed as an artificial manure. The land yields good crops; but after being under the plough for a few years it is frequently laid down again to grass. The peaty soil of Worlaby and other carrs has

a sub-soil of clay often so near that, by ploughing deeply, enough can be brought up to give a solidity to the top-soil,—a condition so highly necessary for the growth of corn and other crops. When the clay is too deep to be thus raised, it is trenched, the trenches being parallel, and about 5 yards apart. The clay thrown out on both sides covers the land, and after being pulverised by the frost and well intermingled with the peat, gives the soil the requisite degree of strength and consistency. The next operation is liming. From 4 to 5 chaldrons per acre are used, the expense of which, including the labour of putting on, is about 15*s.* per chaldron. The first crop is cole, which is always fed off in the autumn or early part of the winter. The same kind of artificial manure is drilled in with the seed that is made use of on the wolds, viz., bones raw or dissolved, guano, &c., and mixed with ashes. Turnips are not much sown, on account of their liability to produce "fingers and toes." Wheat is the next crop, mostly white varieties; but this being subject to injury from water and naturally dependent upon the nature of the seasons on such land, there is great uncertainty both as to the quantity of the yield and the quality of the grain. Occasionally large crops are produced, of 5 or 6 quarters per acre. The weight varies from 15 to 18 stones per coomb, the yield being as variable also; and the better it weighs the more it generally yields. Poland oats follow, the produce very unequal, but not so uncertain as that of the wheat. This crop is succeeded by seeds for pasture, grazed by sheep and young beasts for two and sometimes three years, the former having an allowance of oil-cake, thus putting the land into good heart and a "high state of cultivation." Two white crops are then taken, viz., oats followed by wheat, or *vice versâ.* For a change, beans are sometimes grown on the strongest land, if clean; but the crop is so uncertain that it is not generally sown. Various deviations are of course practised, the most common rotation adopted on the carr land will, however, stand thus:—1. rape, 2. wheat, 3. oats, 4. seeds, 5. seeds, 6. oats, 7. wheat.

On the opposite side of the river Ancholme the carrs are of smaller extent. Below Winterton, Roxby, Appleby, &c., a large portion of the land is being ploughed up, and much has been brought into tillage within a few years. After paring and burning it produces abundant crops of oats, wheat, and rape, to the profit of the occupiers; their former surface having been in some parts a coarse grass of bad quality, and in others a short sharp grass of similar inferiority. No farm-yard manure is applied to the virgin land in the flat; but by boning it for turnips (which are grown on it in this locality), and feeding off the seeds, it brings a great bulk of corn, thus furnishing plenty of straw with

which to manure the *light turnip lands* that require it. On this land, which contains a large proportion of vegetable matter, lime is needed in order fully to develope its capabilities; and the circumscribed area upon which this great stimulator of a vegetable soil has been applied indicates one of the principal deficiencies observable in the management of these carrs. However largely the farmers here may have studied the best way to maintain the fertility of new arable land, it is pretty certain that theirs is not a self-sustaining or permanent system of husbandry. Thousands of acres of the southern Fens have been impoverished by upland farmers taking undue advantage of their untamed strength and richness; and the fenmen who succeed those managers can testify that bone-dust, no matter in what abundance, is no compensation for the loss of all the vegetable and mineral ingredients which the straw would have returned to the soil. Farming seems easy when the land is fat; but the carrs are not inexhaustible, and cannot long bear rifling in favour of the hills. The adoptors of this system, whilst endeavouring to bring the rich and poor soils into a medium state of productiveness, must avoid the unhappy result of leaving both in an inferior condition; and it is highly probable that they would meet with greater success by keeping the products of the good land for its own maintenance, and improving the light land by other means (with the money now spent in bones for the carrs). There is no danger of the carr land becoming too powerful; and as there is no doubt that the new land is actually robbed, suffering by the present method of exchange, perhaps it would be best to reap the benefit of its superabundance upon its own surface, and begin so to do before any important deterioration has occurred.

The characteristics of cultivation that mark the portion already treated of are not found in the more southern carrs, which are bisected by the Ancholme from Brigg southward, because of the greater depth of the peat and the inefficient drainage. A four-course rotation is commonly practised, rape being extensively sown instead of turnips, as it is better adapted to the land. The produce is estimated at a general average per acre of 3 quarters, 6 bushels of wheat; barley 4 quarters, 6 bls.; oats 7 quarters. Fifty years ago the carrs between Bishop Bridge and Brigg were rented at 14*s*. an acre, and that north of Brigg at 21*s*.; the average rental of the whole tract at the present time is about 25*s*. or 30*s*. per acre. The imperfection of the general drainage checks all improvement; let that efficiency in this respect which renders underdraining practicable be once attained, and this long-drowned and deserted level will become as well-cultivated as any other portion of the county.

The next part of Lincolnshire to be adverted to is that between

the carrs and the river Trent, and north of Kirton and Gainsborough; and this may be denominated the *North-western District.* The soils being very various, the modes of management show a corresponding diversity; but by comparing the following details with the description of the soils already given, the reader will be enabled to refer each peculiar practice to its own locality without a repetition here of the names of towns and villages there situated. The general course of cropping on the best kind of land is the alternate one of—1. turnips; 2. barley; 3. red clover for mowing, or white for pasture; 4. wheat. Upon the tolerably good sands—1. turnips; 2. barley; 3. seeds for one or two years; 4. oats or rye. And on the inferior—1. turnips; 2. oats or rye, one, two, or three years seeds, and then broken up for turnips again. On the cold clayey loam the course of cropping varies still more: unless the season be favourable it is difficult to get the land in proper order for turnips, yet, as a flock of sheep is an invariable adjunct of every moderately-sized farm, either turnips or rape are grown if possible, followed by barley, seeds, and wheat. But it is often the case, when a wet or frostless winter and spring occur, that the land will not work well for barley, and if sown at the usual time this crop will not produce more than 2 quarters per acre; and the alternative is to wait till the tough clods become thoroughly dried through, and upon the first heavy rain to roll and harrow them down to a friable mould. Sometimes, however, this cannot be accomplished until too late for the crop; and to avoid such a double dilemma, many farmers take wheat after turnips, followed by seeds, and then beans or wheat for the last crop. By this means one evil is precluded, but another is encountered; it is but seldom that clover will prosper when sown on wheat, for the soil having a tendency to "run" in the winter and set hard when dry weather comes, the seeds are rendered inferior for grazing, and the succeeding crop thereby injured. There are here and there a few isolated disciples of the old school remaining, who follow the primitive course of—1. fallow; 2. wheat; 3. beans; and by their personal labour, the greatest economy in the house, and the expenditure of as little as possible on the land, have hitherto contrived to neutralise the impoverishing effects of the inferior produce of their farms. It was formerly the universal custom to allow the land to remain in seeds for three or even four years, but the period has been gradually shortened of late to only one year.* Another deviation from the general rule has been lately adopted in several localities, viz., that of consuming as many turnips as practicable up to Candlemas,

* With the present low prices of grain it is not improbable that this period may again be lengthened, especially if grazing promise better than cropping: many will be anxious to lessen the expense of labour on their land.

and sowing the land with wheat, followed by seeds or red clover, and wheat again. It is practised upon some of the best red land, being defended by the assertion, that as much wheat as barley is grown after the turnips, and the wheat after seeds is not perceptibly the worse. On the other hand it is said, the seeds and wheat may not suffer in a similar way to those in the same rotation on the clay, but this quick repetition of the wheat crop will only be successful for a time, as even on the best warp soils it is not found profitable to sow wheat oftener than once in three years. Whether or not the cultivation of "half wheat" upon this land shall be found to fail, it ought not to be prohibited by the landlord; in any case where the general management of a farm is good, and the tenant has a strong interest in and attachment to his holding, a new rotation of crops is a matter of profit, and will be abandoned whenever the bushel measure gives its evidence in favour of a return to the former routine. The proportion of swedes to the whole area of turnips grown is not large. On the limestone soil (at Winterton, &c.) good crops of turnips, wheat, beans, and almost everything else, are produced. A four-course shift was compulsorily the custom of the neighbourhood until the last few years. The tenants are now allowed to grow potatoes, and these are of first-rate quality. The line of sand between this and the carrs was inclosed about the year 1777, previously yielding nothing but gorse; good tillage has made it productive, and there has been an extensive use of lime upon it, which fertilizes the soil and destroys the disease of "fingers and toes," to which the turnips were liable. The limestone soil is all underdrained, a lasting improvement being thus insured; and the recurring improvements, such as the use of artificial manures, are also largely practised. Bones are sown with the turnips, generally dissolved, and thus a newly-invented method has become quickly diffused through the district. Guano is likewise much sown with the wheat, costing 1*l.* per acre. Generally speaking, the farm-management on the red and limestone soils is of a superior order, and would bear a comparison with perhaps any part of the county or kingdom, having also progressed more within the last ten years than during the previous twenty.

On the cold and inferior lands the agriculture is more backward, notwithstanding the advances that have been made within the last ten or fifteen years, chiefly from the following causes:—The occupiers have continually to undergo losses from the effects of the season, as well as other drawbacks, being seldom able in a favourable year to do more than recover the loss occasioned by a previous bad one; they are consequently unable generally to farm with that spirit which the wants of the land require, and, if

able, would not possess that confidence in ultimate profit which is necessary to a great outlay, and is present to the minds of those occupying more certain kinds of land.

The produce of wheat varies from $2\frac{1}{2}$ quarters on the moist cold soils and those sands upon which wheat is ventured, to 5 or $5\frac{1}{2}$ quarters on the best land. Instances are not wanting where 6, $6\frac{1}{2}$, or even 7 quarters are attained, but they are rare, and caused by a combination of favourable circumstances having little connexion with the district at large. Barley yields from 3 to 8 quarters; on the cold land 4 or $4\frac{1}{2}$ quarters would be a full average, whilst on the limestone the produce ranges from 5 to 8 quarters. Oats are not extensively grown except on the sands, where from 4 to 10 quarters are obtained. Where beans are cultivated the yield is from $2\frac{1}{2}$ to 4, and occasionally 5 quarters; but they are mostly confined to the cold lands, for though the other soils would grow them they do not make a part of the course, and are most favourable to the growth of weeds, notwithstanding repeated hoeings. Red clover is becoming very uncertain upon the dry lands: it appears thick enough during the autumn and until the February frosts, when whole fields of it will often be three-fourths destroyed at once, the hitherto healthy-looking green plants appearing like black tea, and may be taken up without effort by the finger and thumb. Nothing has yet been discovered as a preventive of this occurrence. Turnips are also more difficult to raise in full plant than formerly; and it is found that to put in a crop of potatoes in their stead, where they are peculiarly liable to fail, is an excellent plan, the turnip-crop at the four years end being doubled in weight. This remedy has not been extensively tried as yet; for on the one hand, the upland potatoes are affected with the mysterious epidemic, and on the other, it is required by the landowners that, when this method is resorted to, extra manure should be purchased.

The sheep are principally of the Leicester breed, and the wool on the average of breeding flocks, composed of one-third "she hogs," may weigh at the rate of 4 fleeces to the tod of 28 lbs. The greater portion of the "he hogs" are sold at Caistor fair and Kirton market when a year old, though many are fed at home. At Roxby the farmers do not breed their sheep, but buy hoggets, and feed them during the ensuing winter, selling them at the end of a twelvemonth from buying in, thus securing 2 fleeces of wool from each sheep. But this method is exceptional to the custom of the district. The cattle are of the old Lincolnshire breed, crossed for the last fifteen years with good short-horn bulls, the produce comprising many excellent beasts. Very few of these are stall-fed, but a considerable number of

Irish heifers are summer fed. The practice of giving 2 or 3 lbs. of linseed cake daily to the young cattle and those in the straw-yard has much extended itself of late years.

With regard to the larger improvements in this district it may be observed that the principal part of the cold wet land (as well as the limestone soil before-mentioned) has been furrow-drained, the landlord furnishing the tiles and the tenant the labour. In some cases, from an over anxiety on the part of the farmer to go over as great an extent of ground as possible at as little cost as might be, the tiles have been put in at too shallow a depth, and will of course have to be relaid before an effectual drainage is established. Formerly the principle universally acted upon in drainage was, that if the top water were taken out of the furrows, the nearer the tiles were to the surface the better, provided they were out of the reach of injury from the plough; but more recent experience has proved that the majority of soils are benefited most by a deeper drainage, and that with a sub-soil kept clear of water, that which falls from the clouds may be safely and serviceably left to percolate through the soil and descend to the drains by its own gravity. Another defect in the execution of the work was the inattention bestowed upon the outfalls; the depth of the cuts being often determined by the state of the ditches, instead of these being put into proper order at the outset. The system of claying the sand land is carried on upon a large scale, where the clay can be procured at a convenient distance. It is applied at the rate of 100 loads per acre, and is attended with the most lasting and useful effects; but it has been proved that a better method is to lay on about 70 loads per acre, and then after 2 or 3 years to add a second covering of equal amount. The sand upon which this is done is of the weakest, lightest, and loosest description, too barren in its natural state for any other purpose than that of supporting the numerous plantations which overspread it: not only, however, does a wide proportion of it lie in sterility and waste, but (after the pattern of the Dutch wastes of water) becomes dangerous by its encroachments upon the surrounding land. Clouds of sand will arise in a hurricane, and, like a simoom of the desert, bury large tracts of verdure and fruitfulness; and as an instance of what a light sand can thus destroy, it may be mentioned that on a farm at High Risby are more than 100 acres of first-rate land blown over at some former period with from 2 to 3 feet of arid sand from the warren, and rendered thoroughly worthless. The clay stays the sand from blowing, and produces good turnips and seeds, which in their turn enable the land to grow good corn; the sand being more profitable to rent after claying than to be rent-free before.

Artificial manures are freely applied to the dry turnip lands,

but on the strong soils experience has decided that their action is uncertain and not remunerative.

The warp or alluvial land, near Alkborough, is mostly meadow or pasture, and the little that is under the plough is generally cropped with wheat every other year, alternated by beans on a dead fallow. Some of the best land, when fallow, is planted with potatoes—no regular system being observed. Over the larger tract, stretching southward from Burton along the Trent side, vast quantities of potatoes are grown, contributing largely to supply the London market with "Yorkshire" Regent potatoes; and wheat is produced at the rate of 6 qrs. per acre. The courses of cropping are very irregular, but, as a general rule, wheat is sown every third year, and upon the fresh land every alternate one. The rotations are something like the following:—

1. Potatoes; 2. Wheat; 3. Oats; 4. Clover; 5. Potatoes; 6. Wheat.
1. Potatoes; 2. Potatoes; 3. Wheat; 4. Clover; 5. Clover; 6. Wheat.
1. Potatoes; 2. Wheat; 3. Flax; 4. Clover; 5. Potatoes; 6. Wheat.

Though many warrens exist upon the blowing sands of this district, and also in various other parts of Lincolnshire, they are not conducted with such system and arrangement as in former times, and are regarded more as a dernier resort for weak land than a profitable mode of husbandry. Their importance is not of sufficient weight to claim a particular notice in a description of Lincolnshire farming, but as an idea of the mode of cultivation which is practised upon them, it may be remarked that, many years ago, when warrens were extensive, it was customary to plough a part every year for corn and turnips. Seeds were then laid down, and the fences broken down for the rabbits to enter. In winter, and during a snow-blast, they were fed with ash-boughs, gorse, oat straw, sainfoin, turnips, and clover hay. A thousand acres of land might be stocked with 2500 couples of rabbits, which, in a storm, must have 2 loads of hay, or 2 or 3 large waggon loads of turnips daily. Out of this number about 5000 couples might be killed annually; six-score couples being sold for 10*l.* or upwards; and the town of Brigg had several large establishments where the skins were prepared. The chief sorts were the "silver-hairs" and "grey-skins." The principal expenses, besides the production of the food, were the facing and capping of the banks round the warren—these being generally worn down in 7 years—and the purchase of traps, nets, and thread, and charcoal for drying the skins. At the present day there are few temptations to a renewal of rabbit-breeding, the localities once famed for these vermin having risen to a more honourable renown by the superiority of their flocks and herds. The remaining warrens, however, on those places only which bid defiance to the plough and presser, are (as formerly) "a horrid

nuisance to the neighbours' corn, new seeds, turnips, and, above all, to the quicks, which they presently destroy; and the land presents to the eye a melancholy scene, more of desolation than culture."

The fields in this district vary from 6 or 8 acres to 12 or 16 acres on the cold land, and from 10 to 50 acres on the sand and limestone; and in some parts are far too heavily burdened with hedge-row timber, especially on the strong land, whilst large tracts at the same time exist that are well adapted for planting, though nearly useless for any other purpose. Though the present price of ash and elm timber offers but small inducement to the owner to sell, the welfare of the tenantry imperatively demands the removal of trees from the fences, and (as remarked by an intelligent farmer in the district) "points to a period by no means remote, when the toast of 'Rabbits in a warren, trees in a wood,' shall have reference to a reality and not to a nonentity." The same gentleman (to whom the public are indebted for the greater portion of the facts given respecting this district) remarks:—

"There are many plantations on the inferior sands, but they ought to be greatly extended, and would thus beautify the country, admit of a clearance of the present hedgerow trees, and provide an abundant supply of superior timber for future generations, besides doing away with the practice of planting trees in young hedgerows, which is akin to the inoculation of a child with the seeds of consumption. It is a general observation that the establishment of a plantation in any locality is the destruction of the occupier's profit on all the surrounding fields: I would observe that it is not an inevitable accompaniment; and, with the increasing conviction on the minds of the landowners of the necessity of paying a regard to the tenants' welfare, will soon take its place amongst the hindrances to agricultural prosperity which *were*. The impediments to the improvement of a property where the owner has but a life-interest in it are neither few nor small: and this neighbourhood furnishes more than one illustration of it. On one estate the Humber is suffered to encroach and carry away acres of first-rate land each year, when a vigorous effort would not only prevent any further loss, but regain hundreds of acres from the dominion of the waters. On another, a narrow parsimony has kept it in a wet state, and prevented any further improvement on the homesteads. Whilst on a third a large tract of inferior land on one side of a village, though capable of improvement, remains a common, pastured by rabbits, with a few Scots and half-starved sheep; and another piece on the opposite side, of many hundred acres in extent of low moor and sand, several feet lower than high-water mark in the Trent, remains in its primitive barrenness, although abutting on the north and south upon other lands formerly in the same state, but by the process of warping producing the richest crops of wheat, beans, clover, potatoes, and flax. And this land has a large warping drain on its south side, with another equally convenient for the purpose on the north, ready to flood it with the rich muddy water of the river several feet in depth in a single tide."

Among the wastes yet remaining are Corringham Scroggs, of about 2800 acres, and Scotton Common, of nearly 3000 acres;

the soil and aspect of the latter has been described in the first part of this report. It is a wild moor, grazed in summer by beasts and sheep, which must have great difficulty both in traversing its tangled heath and boggy rivulets, and in finding provender. All the land is high, and is therefore well situated for drainage; but some persons are of opinion that it would grow nothing if cultivated. Some portions may be thus infertile, but where herbage now grows better herbage might be made to grow; and similar tracts in its vicinity have undergone the improvement of drainage and ploughing with success. Near to the village is a clay soil, which might be mingled with the light peaty sand, and cause the production of good crops upon land that will grow but little of itself. It is a sudden blow to the feelings of an agriculturist when he enters upon this dreary region of unprofitableness, no matter on which side he approaches; for on the one hand it will present a sudden contrast to the highly cultivated Cliff, and on the other the surface will appear to change instantaneously from the prolific Warp, clad with rich produce, to a blasted scene of blankness and sterility. The inclosure has been hitherto delayed solely because of the private considerations of the chief landowners in the neighbourhood.

The rental of the district, which has now been reviewed, is from 4*s*. to 15*s*. per acre on the common sands; 15*s*. to 21*s*. per acre on the cold soils; 21*s*. to 28*s*. per acre on the better heavy land; and 30*s*. to 35*s*. per acre on the red soils and limestone; up to 42*s*. per acre on the smaller properties on the limestone, and on the warp lands; generally tithe free.

From the lofty hill summit at Burton-on-Stather the *Isle of Axholme* is seen stretching out for many miles beyond the broad-flowing and winding Trent—an immense plain, luxuriant with pasture and clustering foliage among its dark arable fields, intersected by long lines of drains, and exhibiting bright shining spaces where distant warping-works are in progress. The richness of the scenery is not delusive, for on descending to the flat, and entering upon the wide plain of warp, and again mounting the elevated land of the Isle, the fertility and cropping are found to be of first-class order and abundance. The total quantity of land is 50,590 acres, and when 10 per cent. has been deducted for waste, roads, drains, fences, &c., there remain 45,531 acres of productive soil. The principal portion of this is arable, as the grass land is scarcely one-seventh of the whole. The Warp land, or alluvial deposit, occupies about 14,688 acres, and contains three classes or qualities of soil. On the first class soil the rotation is generally wheat and potatoes alternately, for many years together (in some cases as many as 50 years), without the introduction of a fallow or any other kind of crop; occasionally, however, there is

sown a "running" crop of beans or seeds. The second class quality produces an intervening crop of beans, barley, oats, clover, flax, turnip-seed, or onions between the wheat and potato crop, but seldom has a naked fallow. The third class land is managed in a four-course shift, *viz.*, 1. fallow, part sown with rape or turnips and eaten off, part planted with potatoes, and part naked fallow; 2. wheat or oats; 3. clover pastured, seeds, or beans; 4. wheat or oats. The warp land forms the great potato district in the Isle of Axholme (and an equal extent is annually planted in Marshland, Yorkshire), and the immense extent of land annually set with these roots is apparent from the above rotations, amounting actually to upwards of one-third of the land, the larger farmers often having 250 or 300 acres of potatoes each. Potatoes are generally planted after "line" (flax), beans, or seeds, not after wheat. An extensive grower at Amcotts pursues the following rotations:—1. fallow; 2. potatoes; 3. wheat; 4. beans; 5. potatoes; 6. wheat: and 1. fallow; 2. potatoes; 3. wheat; 4. oats; 5. seeds; 6. potatoes; 7. wheat. A new method of potato farming is to plant after seeds, and is considered to be the best practice. The tendency of the land is to produce a fine and large ear and beautiful corn, but a weak straw; so that when bursting into ear the crop falls, and, by being thus early laid, loses a great deal of grain. The mode of culture adverted to in a great measure obviates this. The clover is mown once; the second growth then comes up, and when in full bloom receives a dressing of yard-manure, and is ploughed in. This is done at "half-depth;" and the land is next deep-ploughed and left for the winter. In spring the rotting clover-stems have made the soil in fine order for receiving the potato sets; and after this manuring, and the growth of the potatoes, a strong bulky wheat-straw is produced, bearing a remarkably good yield of grain. It is recommended to plant potatoes *whole,* and either in November, February, or March, if possible. The manure used for the potatoes is the best horse and cow dung from Hull and London, brought by sea in the vessels which carry the produce to market, and from Leeds and Sheffield by the canals and rivers. Fifteen or 20 tons per acre are commonly applied, costing 7*s.* per ton; or occasionally 6 cwt. per acre of the best guano is used, several of the best potato planters expending as much as 10*l.* per acre yearly in manuring their respective potato crops. The lands along the Trent side are not all equally well managed, so that soil, naturally of one uniform quality, will appear by its variable crops to be better or worse; the general farming of the warp land, however, is of the above superior order, so that rich alluvial soil, which nearly everywhere else lacks the high management

observable on poor land, is in this district made to exhibit the peculiarity of costly manuring and indefatigable weeding. A hundred sacks (16 stones each) per acre is a common amount of produce, and often 120 or 130 sacks per acre. After the manured potatoes have been grown the land will bring 5 quarters per acre of wheat, but the average is of course much less. The average produce and breadth of each kind of crop on the warp land is as follows:—

	Acres.	Crop.	Acres.	Yield per Acre.
First Class quality .	2000	Potatoes .	1000	100 sacks, or 10 tons.
		Wheat . .	1000	36 bushels.
Second Class quality	8000	Potatoes . .	2666	80 sacks, or 8 tons.
		Wheat . .	2666	30 bushels.
		Beans . .	1000	32 bushels.
		Oats . . .	300	48 bushels.
		Onions . .	68	10 tons.
		Flax* . .	300	$0\frac{1}{4}$ ton (70 stones have been grown).
		Clover, Seeds, &c.	1000	
Third Class quality . .	3563	Potatoes . .	300	60 sacks, or 6 tons.
		Wheat . .	890	24 bushels.
		Oats . . .	893	40 bushels.
		Clover and Seeds.	890	
		Fallows . .	590	

Of the total quantity of warp land, *viz.*, 14,688 acres, only 1125 acres are under grass. The rental per acre is from 30*s.* to 60*s.*, but is sometimes as high as 80*s.* or even 100*s.*

The high grounds, extending through Haxey, Epworth, Belton, and Crowle, are adjacent to the above alluvial district, and comprise two varieties of soil. The clay loam, about 10,116 acres, has 1850 acres of grass; the usual course of cropping on the arable land is 1. fallow; 2. wheat or oats; 3. clover, seeds, or beans; 4. wheat or oats. The extent and produce of each kind of cropping is as follows:—

* The following, we believe, is the common method of culture for flax. The land, usually wheat stubble, is cleaned in the general fashion; the seed is sown in May, the crop carefully weeded, and when the plant is gone out of flower, about a week after Midsummer, it is pulled and bound in sheaves or beats; then carted away to the pits or dykes, covered with sods, and left to steep in the water from ten days to three weeks according to the weather. After being taken out of the pits it is spread on grass land for about three weeks, then again bound up in sheaves, taken home, and stacked for dressing. The expenses, including "hackling," are estimated at about 13*l.*; the produce, 35 stones at 9*s.*, 15 guineas.

	Acres.	Crop.	Acres.	Yield per Acre.
Clay Loam, arable .	8266	Wheat . .	3632	28 bushels.
		Beans . .	1000	24 ,,
		Oats . . .	500	48 ,,
		Clover and Seeds.	1066	
		Fallow . .	2068	

The rental is from 25*s.* to 50*s.* The principal part of the sand loam, or rich barley soil, is open-field, managed without sheep, and a great part of this is employed for growing vegetable produce for market. The open fields are tilled by innumerable small farmers, who have a rood here and a rood there, laid out in broad curved lands or stetches without any kind of fencing or ditch, the whole resembling a succession of gardens or allotments rather than farms. It is impossible to lay down any regular system of cropping for this section of soil; but its general production is wheat, oats, beans, barley, potatoes, onions, carrots, flax, turnip-seed, mown-clover, turnips pulled off—seldom or never consumed on the land. There are no pastured seeds. Wheat is the least profitable of their crops; on the other hand, the carrots and onions with which they supply Doncaster and Sheffield markets are highly remunerative; success with these crops depending mainly upon good weeding. As much as 25 tons of carrots per acre have been grown, the expense of weeding them, however, being very heavy, often 4*l.* 10*s.* or more per acre. The number of acres under each sort of cropping and the amount of produce is shown in the following synopsis:—

	Acres.	Crop.	Acres.	Yield per Acre.
Sand Loam, arable .	6622	Potatoes . .	1000	80 sacks, or 8 tons.
		Wheat . .	1000	32 bushels.
		Wheat . .	1297	28 ,,
		Barley . .	775	40 ,,
		Oats . . .	387	56 ,,
		Beans . .	388	24 ,,
		Turnips . .	500	
		Flax . .	100	$0\frac{1}{4}$ ton.
		Carrots and Onions.	175	10 tons.
		Clover . .	1000	

Of about 7272 acres of sand loam 650 acres are in grass. The rent is generally 3*l.* or 4*l.* 10*s.* per acre, but varies from 40*s.* to 100*s.* per acre. West of these high lands is the flat tract of low sand and peat, containing about 13,455 acres, of which 2800 acres are under

grass. The course of cropping is the four-field system, *viz.*, 1. turnips; 2. barley or oats; 3. clover and seeds, pastured or mown; 4. wheat or oats. It is upon this light and peaty sand that the warping is chiefly done; further westward, where the peat becomes deep and spongy, as about Wroot, &c., the course is, 1. turnips; 2. oats or wheat; 3. seeds; 4. wheat or oats, or just the same as on the sand, only substituting oats for wheat and barley. This black peat is beyond the reach of the present warping drains, and it is of such a depth that the clay upon which it rests is not near enough the surface to be useful. In one locality clay from adjoining land has been carried on to it, and the tender bog thus covered over with 5 or 6 inches of good soil. This was done by laying down tram rails of 6-inch timber, with an iron flange upon each of them, the earth-waggons having iron wheels to correspond. The cost of this improvement is 10*l.* to 15*l.* per acre.* The following is a table of the extent and yield of each crop:—

	Acres.	Crop.	Acres.	Produce per Acre.
Sand and Peat . .	10,655	Wheat . .	2000	24 bushels.
		Barley . .	800	32 ,,
		Oats . .	2527	40 ,,
		Seeds, &c. .	2664	
		Turnips or Rape.	2664	

Rape or coleseed used to be much more widely grown than at present, when the surface now warped was moor, the custom being to pare and burn the seeds for the rape. This crop is eaten off, occasionally grown for seed, and sometimes fed off and then allowed to stand for a crop of seed. The rent varies from 10*s.* to 35*s.* per acre. The number of sheep in the Isle of Axholme is but small. About 4500 ewes are kept as breeding stock, and their produce, or 4500 hogs, are annually sold. Besides these, about 4500 sheep are annually bought in, fed, and sold off fat. The wool is estimated to weigh about 4½ fleeces to the tod of 28 lbs. About one beast for every 11 acres is the proportion yearly bought in at autumn as store cattle for winter and sold in the spring, a part of them being fattened. A considerable quantity of linseed oilcake is used for cattle food, and also of rapecake for dressing the land. Bones and bone-dust are used to some extent for turnips on the high land. Underdraining effects the most useful results upon all the soils; but

* For an interesting description of this mode of "dry warping," see Journal, vol. xi. part i. page 180.

with the open fields and the low lands yet imperfectly drained, in the absence of steam-engines, there is much land which yet requires the commencement of tile-draining, or its improvement by executing it at a greater depth. The warp is strong land to work; and among the implements is the same peculiar plough which is used in the eastern and southern lowlands of Lincolnshire, *viz.*, the Yorkshire two-horse swing-plough, furnished with a "skeith" instead of a straight coulter. It is a small wheel or disc of iron, sharp at the periphery, running level with and close to the ploughshare, and is preferable to the coulter where the land is strong and perfectly free from stones. The Isle of Axholme waggons are of a peculiar construction, and very useful; they are very light, with narrow wheels, and are made with a pole like a coach, so that either a pair or 3 or 4 horses can be attached.

The roads were in a very bad condition forty years ago, but there are now some excellent thoroughfares constructed of material from the Yorkshire coast. The bye-roads are still miry in wet weather, and would be almost impassable were it not that a narrow pavement of flagstones, termed a "causey," is generally found alongside, affording a firm and expeditious pathway for the foot passenger and equestrian.

The occupations are remarkably small in the Isle of Axholme, 300 acres being considered a large farm. In the parish of Haxey there are only three or four farms of 250, 300, or 400 acres each, half of the remainder being less than 50 acres, and the rest under 10 acres; whilst roods, half acre, and acre pieces are general on all the open field land. This minute subdivision of the soil into so many holdings suggests a comparison with some districts in Ireland, where squalid poverty is seen attempting to cultivate similarly small plots of equally rich land; but the likeness exists only in the partition, not in the management, of the land, and the condition and habits of the people are widely different. It is true that in some respects the open field lands are not so well cultivated as the larger farms; underdraining cannot be well done where nearly every land (5, 10, or 20 yards in width) belongs to separate men, and neither can the grazing of sheep be practised; but in the tillage and pulverisation of every inch of the soil, and the constant and complete cleaning of the land and the crops, the small farmers have a good substitute for many agricultural improvements. Their land is chiefly managed by the spade, hoe, and fork; though many keep a horse and plough, &c., for themselves and neighbours. They are very industrious, and, as industry creates its own reward, usually meet with success in their cropping. Many may be poor, but as a general rule they are well off, earning for their families an independent livelihood.

Labour is the principal expense on this land, and as that is all done by themselves, they are well able to stand against an occasional failure of produce. They bid great prices for land, and pay in some cases 4*l.* and 5*l.* per acre rent; so that considerable estates here have lately been sold at 70*l.* or 80*l.* per acre. Yet, even in these cheap times, many of them are obtaining large profits. The *Stamford Mercury* of November 9, 1849, gave an instance of what labour accomplishes upon this land:—"One small cultivator of the name of J. Fowler, of Haxey, has bestowed remarkable labour and attention to 4 acres of potatoes, which are of the sort called Regents. The sets were put into the ground at the beginning of May. After they had made their appearance, he loosened the earth between the rows with a fork, and made the soil as friable as possible: they were afterwards hand-hoed. The crop was ploughed up a few days ago, and produced 70 loads per acre, of 18 stones to the load, and fetched in the market 7*s.* 6*d.* per load. The quality was as fine and sound as can possibly be imagined. Thus these 4 acres have produced 280 loads, or 5040 stones, and realised the sum of 105*l.*, or 26*l.* 5*s.* per acre." There is also further reason why these small holders should not be compared but contrasted with the people of the same class in Ireland,—they are as much noted for their morality as their diligence. A correspondent in the northern part of the Isle affirms that the inhabitants generally are "industrious, tolerably honest, and persevering;" whilst the following is the character drawn by an intelligent and trustworthy observer in the south:—"The small farmers, or occupiers of the open field land, in the Isle of Axholme, are a most active and industrious class of people; they are collectively moral, sober, and industrious. I know no district so totally devoid of crime of every kind:—petty larceny exists to a very trifling extent, and the more serious offences are unknown." How is it that the character, habits, and condition of these people are so opposite to those generally portrayed of the Irish cultivators of the same class? Another striking difference between the Isle of Axholme and Ireland will probably hint a solution to this inquiry. There are very few middlemen or underletters, and there is neither a monopoly in the ownership of the land nor a race of absentee landlords, as in Ireland. Here the occupiers are frequently owners, or at any rate they may become owners by a thrifty industry, and thus it is a prospective as well as present advantage that stimulates their energy; for the land here is not kept by law, to any large extent, out of the market, so as to subject the remainder to an undue competition, and thus check the efforts of those who aspire to purchase and possess it. The open field and other lands belong to an immense number of proprietors, many of whom, while farming their own land, also let a

portion to others, the tenants being perhaps four times as numerous as the freeholders. As is the case with larger estates, many of these small properties are mortgaged; but those persons who imagine that small parcels of land and allotment-farming tend to poverty, and that prosperity is found only on larger domains and occupations, need not seek in this district for a confirmation of their notions. It is the owners who have mortgaged that are in the most depressed circumstances, having purchased more land than they had capital for; and thus where poverty is felt it is from possessing too *much* land rather than too little. Let it not be supposed that these statements are made with a view of deprecating the employment of capital in agriculture on a large scale—they are brought forward as a matter of fairness; for, having shown the success of large farms where they seem to be actually needful for cultivation at all, it is proper to exhibit the equal success of garden farms in localities just suited for the system. The trampling of the flock and the expenditure of cash in manures are required on the Heath and Wolds, and there the man whose chief capital is in his sinews would be at fault: on the rich loams of the Isle, however, toil is the principal requisite; and the working farmer is far more qualified than the man of money, scientific implements, and improved breeds, to follow out the comparatively microscopic detail of spade husbandry.

This Report is unavoidably hasty and incomplete owing to the variety of subjects it embraces, and the number of districts in connexion with which those subjects have to be considered; but however hasty and superficial, an account of the *process of warping* cannot be omitted, forming as it does a remarkable peculiarity of the district around the upper end of the Humber, and along the great streams which communicate with it. A detailed account of this process, and of its improvements in Yorkshire, has already appeared in the Journal,* but a much more extensive tract of land has been thus treated in Lincolnshire; and this part of the Report has been chosen for making a few observations on this subject, although it is difficult to say whether warping is most allied to draining or farm management, or whether it ought not rather to be noticed under the head "Soils." It appears that warping was first practised about eighty or ninety years ago, though only in a very small way; and previous to the year 1800 probably not more than 1000 or 1500 acres in this county had been warped.†

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* Journal, vol. v. 1845, by Ralph Creyke, Esq. of Rawcliffe, near Selby, Yorkshire.

† In the "Annals of Agriculture," vol. xxxvii., 1801, are some extracts from "An Hydraulic Essay on Embankments, by Signore Al. Leonardo Ximenez, Hydrographer to his Royal Highness the Grand Duke of Tuscany," from which it appears that though

The first step in the process is, to erect a sluice in the bank of the Trent or other tidal channel, and cut a main drain to the fields which are to be flooded. The sluice-doors point outwards so as to exclude the tides, except when held open by rods and staples provided for the purpose; and the drain ought to have an area equal to three times that of the sluice, in order to prevent any considerable resistance to the flow of water. The land is then surrounded by an embankment, of variable altitude according to the level of the surface, and from 2 to 3 feet wide at the top, the usual slope of the banks being from 15 to 18 inches on each side for every 12 inches perpendicular rise. The tide flows rapidly in, and, meeting with no obstruction to detain its current, holds in suspension the particles of sediment with which it is loaded; but directly it leaves the narrow channel and spreads itself over the broad surface, the rapidity of motion is lost, and the atoms of warp, no longer projected forward, sink quietly to the bottom. A deposit is thus formed, greatest near the mouth of the drain; and in order to equalise the amount of warp over the whole ground, the water is conducted to different parts of the compartment by smaller drains called "inlets." When the deposit is raised sufficiently high next to the ends of these channels, the current is carried forward by extending the banks of the inlets in different directions; and thus by a skilful and careful guiding of the water the whole of the land is warped to an equal height. The water is conducted by a temporary drain, first to the further side of the plot; and when the deposit there is sufficiently high, is allowed to escape at intervals along the sides of this drain, until the whole area is equally raised. The tide, having thrown down much of its mud, returns by the warping-drain into the river, scouring out the sediment which might have accumulated in the drain. The water must be allowed to run off so as not to leave too much in the compartment or impede the entrance and passage of the next tide through the drain. In the Isle of Axholme any proprietor, whose land lies adjacent to any of the

warping had then been known in Lincolnshire and Yorkshire, between thirty and forty years, in Italy it had been long practised. Sluices also were invented in that country and the first navigable canals made that were known in Europe. Towards the close of the 17th century, "in the territory of Pisa, the engineer Ciaccheri erected a sluice, under which he made a canal to convey the water of the Arno for the length of two miles to a situation to be warped. This was done in the reign of Cosmo III., of Medici." This paper, written in 1777, likewise affirms that the process was then very general,—"all the territory of Valdichia warps, and whatever deficiency may ensue in the produce of their meadows during the warping, yet when it is effected their crops are so abundant that it makes amends for the loss of the first years and the expense of embankments." They had learned to conduct the currents in such a manner as to prevent the accumulation of sand-beds, and equalize the depth and quality of the new-made soil. The mud collected was not that of the sea, but the slime borne by the rivers from the uplands, and which formed in time of floods about 3 per cent. of their whole volume,—from 30 to 40 inches of water depositing 1 inch of warp.

public warping-drains, may cut through the bank and make use of the water, and if another property intervene, land must be purchased through which to cut a drain. The usual payment is "full-price for *cut* and half-price for *cover*," *i.e.*, full value for land occupied by the drain and half-price for the soil covered by the banks; but as the seller retains possession of the banks (for grazing, &c.), the latter price may be considered more as a payment for privilege than a remuneration for sale. Any person erecting a sluice in the river bank must give his bond to the Sewers Commissioners to pay all damages in case of an accident. Generally speaking the spring tides only are used, as they have sufficient volume of back water to keep the warping-drains clear and open; and the land is raised from 1 to 3 feet in one or two years. When peat-land 9 or 10 feet in depth (as Crowle Moors) has been warped, the surface subsides, after several years' cultivation, in consequence of the spongy moor settling under the weight of warp, and it is then necessary to warp a second time. Some small plots adjoining the rivers have been warped three times. The expense of warping is very variable; when the cost of the large drains and other works is included, the calculation would probably be 12*l.* to 20*l.* per acre; but on those lands immediately contiguous to the public warping-drains (made at the inclosure in 1795) the expense of flooding is only about 2*l.* 2*s.* Within the last thirty years all the peat-land within three miles of the Trent (in the Isle of Axholme) have been warped, the drainage thus greatly improved, and the soil, from being almost worthless, made worth from 60*l.* to 100*l.* per acre. The custom is not to warp a whole estate at once, but to do one, two, or more fields each season; so that the total quantity of land now under the process is not great, although when multiplied by the number of years during which the practice has been continued, the area that has been completed is very large. A gentleman, who has kindly furnished the principal part of the facts and the statistics that have been given respecting the Isle of Axholme, calculates that about 9000 acres of land in the Isle, and the district of Marshland in Yorkshire immediately adjoining (without including the warp lands *east* of the Trent), have been warped by the Trent and Ouse since the year 1800. At present about 600 acres are under the process, and it is probable that the same quantity of land will be warped annually for some years to come. The warp is a long time becoming solid: at first it cannot be walked upon; but there is much difference in its nature owing to the various gravities of the particles floating in the currents directed over the land, and a sand-bed soon grows stiff whilst a strong warp is a long time in setting. It is first surface-gripped at the back-end of the year, being laid out in 4 yard lands, allowed

to lie all the winter without further preparation, and then sown in spring. The first crop is oats, merely to shelter the seeds sown with it: these are grazed with sheep two years, so as to let the salt drain out of the land, and also to enrich the soil. The next crop is wheat, and is often sown for three or four years in succession. Many farmers, anxious to begin of the large yields, graze the seeds only one year, and then break up for wheat. The new warp appears spontaneously to produce fine white clover, and brings weeds never seen on the same surface before, particularly mustard, cresses, and wild celery, with plenty of docks and thistles.

Underdraining is the first thing done upon new warp land—and, indeed, upon all other sorts in the neighbourhood—the warping giving a much greater fall for the drains into the ditches. Clover, or red and white clover and rye-grass, is recommended as the first crop (of course protected by oats during their growth), and the main reason is, that the soil, having been recently deposited by the action of water, is liable to run together in any continuance of wet weather. Such being the case, it is highly desirable to keep the land open by adding a certain quantity of *fibre*—the clover-roots give that fibre. Wheat and potatoes are the staple produce of warp land, with occasionally beans and line; the land being freshened, as it were, by seeds, should fallow not be necessary.

The warped lands east of the river Trent have nearly all been made since 1800; all the larger warping-drains in that district having been cut, and all the *great* improvements commenced since that period. There are some places where the warp was not laid on sufficiently thick to give the land a good natural drainage, having been done 30 or 40 years ago, when there was neither patience to allow it to be done well nor a sufficient expense gone into by the owner. There was great anxiety to begin to crop the land as soon as possible, and the water was shut off much too soon, according to the modern system of warping: this circumstance, together with the fact that the spongy peat-moor has been settled and consolidated by the weight of warp above it, has not given those lands a sufficiently good drainage when cut into fields of from 6 to 10 acres each, and they will ultimately have to be re-warped, at a cost of from 7*l.* to 10*l.* per acre. Nearly 7000 acres have been warped since the year 1800 on the east bank of the Trent; the work is still progressing, and many hundred acres of peat and sand have yet to be covered by this process with a bed of the richest soil. The first crop on the warp here is Seeds, a little rape being occasionally sown with it; then beans, then wheat, then flax, and after this wheat again; by which time the land will be foul enough to need a fallow, as couch-grass propagates amazingly in this soil.

Warp lands are in general much over-valued; it being the opinion of those best able to judge, that when wheat is at 60*s.* per quarter, the rent of the general quality of warp ought not to exceed 2*l.* per acre. Abutting on the Trent, where potatoes are largely grown because of easy shipment, and on the natural warp, where "wheat and potatoes" is the course, the rent is necessarily higher. It is difficult to say from whence the mud or warp is derived, which has been deposited in a vast bed of more than 16,000 acres in extent and more than 2 feet in thickness, and still leaves the Humber no clearer than before. Do the tide-waves wash the falling material of the Yorkshire cliffs into this estuary, or is the warp brought down by the tributary rivers? The Humber is comparatively clear at its mouth, and the land-floods always hinder the process of warping. Doubtless the tide scours its thickening slime from the bottom of the estuary, this again being slowly and imperceptibly supplied by mineral and animal matter both from the rivers and the sea. Freshwater floods drive back the tidal warp by their violence, thus lessening the amount of deposition in the works; but the sediment they contain, after mingling with that already in the Humber, is taken up by the tide and carried back again into the rivers. It is from this intermixture that the peculiar fertility of the alluvium is derived, the Humber forming a vast receptacle exactly adapted for the mingling of the various marine substances with the mineral and earthy matters of the Ouse and Trent waters, and for receiving the exuviæ of myriads of animalcules that float in the fresh and salt streams, and perish where they meet.*

Attention is next requested to a few cursory remarks upon what may be termed the *Western district,* including the clay and other soils west of the great oolite range between the north-western district north and Grantham south. Although the lias formation constitutes a large proportion of the rich pastures and dairy-lands of Leicestershire and other counties, there is but little dairy produce made upon it in Lincolnshire. Cheese is rarely manufactured in any part of this county; and in the division now under review butter is scarcely ever made much beyond the supply of domestic wants. The proportion of grass-land northward of the Foss Dyke is small, and the land is cultivated for wheat, beans, oats, barley, and seeds. Perhaps the most general course of cropping is after the four-field system. Rape is much grown on the stiff soil for feeding off, but none for seed. Barley on the lighter lands produces on an average about 5 quarters per acre; wheat generally yields 3½ quarters. Liming is done on the

* For an admirable account of the process of Warping, and the chemical analysis of the new-made soil, see a Paper by F. J. Herapath, in the Journal, vol. xi. part i.

clay, and on the deep soil which lies next to the Cliff. It is usually spread out of carts and ploughed in upon the fallows, but it is thought that the best mode upon these kinds of soil is to put it in small heaps, cover them with earth, and when the lime has fallen into dust spread and plough it in. Different soils require a corresponding variation of treatment; where there is much vegetable matter in the land, the caustic or quick lime is needed in order to decompose it: but on these soils, whether strong heavy clay or looser soil impregnated with iron, practical experience seems to recommend the application of lime in its mild or slaked state, and it is thus found to be a valuable manure for sweetening and mellowing the soil, and supplying food for the roots of plants. Liming the seeds is found to be a very useful and profitable custom.

Underdraining has been carried on to a considerable extent in that part of this district now referred to (viz. north of the Foss Dike); but the work must be still farther prosecuted. The rent here may be from 20*s*. to 25*s*. and sometimes 30*s*. per acre. Woods and fox-covers abound, and south of the Foss Dike are large tracts of woodland and wild open moors covered with gorse and ling. Many of these waste commons have been lately inclosed. To the west of Leadenham the land is chiefly pasture; it is rich feeding-land of excellent quality, but becomes of less value near the river Brant. A considerable amount of underdraining has been done, and is still going on; that, however, which was completed some years ago has in many instances failed, the drains being much too shallow. The present method in this neighbourhood is to make the drains 36 inches deep where an adequate fall can be obtained.

In the neighbourhood of Hough the surface is fully half under grass; and toward Brandon about one-third is good bullock-pasture, one-third store-land, and the remainder impoverished meadow that has been converted into arable. This is managed on the four-field system, the average produce per acre being 4 quarters of wheat or 5 quarters of barley. In Honington and neighbouring parishes about one-fourth of the land is grass; a large proportion of it is of inferior quality, the rest good sheep-land. The usual course of cropping is a 5 and 6-field system; the average produce per acre is about 4 quarters of wheat, 6 quarters of barley, and 8 quarters of oats. The rental averages about 32*s*. per acre. Most of the land is more or less efficiently underdrained, causing great advantages, particularly on the more retentive lands. Bones and linseed oilcake are used to a considerable extent, and sometimes rapecake; the principal amount of the portable manures purchased, however, are used upon the adjoining Heath-land, of which each parish has a portion.

In Barkston and other parishes skirting the Heath boundary, a line of sand and red land lies between the heath and a tract of stiff clay which stretches westward to the boundary line of the county. On this line the four-course shift is practised, as on the heath; on the clay the rotation is—1. dead fallow, for 2. wheat, oats, or barley; 3. seeds or beans; 4. wheat, oats, or barley. On the poorer clays a 5-field course is preferred, viz., 1. fallow for 2. spring corn; 3. seeds; then break up for 4. oats; 5. wheat. Better wheat is grown after oats than after seeds, if eaten with linseed-cake. The dead fallow is a dead loss, and considerable efforts have been made by the more enterprising during the last few years to grow tares on some portion of the clay fallows. These are partly mown off for horses, but principally eaten on the land with cake-fed sheep. The chief difficulty is in keeping the land clean. Fine turnips can be grown upon the clay; but the farmers do not know in a wet season what to do with them, as they can neither feed them on, nor cart them off the land to advantage. On the sand land the cultivation of swedish turnips has much increased of late years, though they are not so extensively grown as white and green-top turnips. The swedes are probably one-fourth of the whole crop. All are drilled, some on the flat, but mostly upon ridges, varying from 18 to 26 inches in distance apart. Swedes of very good quality have been grown on the sand; the land being ridged, manured with 10 cart-loads of oilcake yard-manure, and 4 cwt. of gypsum, with from 15 to 20 cwt. of turf-ashes drilled in with the seed. The average produce of this part of the district, which is well farmed, is of wheat 4 quarters, barley 5 quarters, oats 6½ quarters per acre, and beans and peas for the last 5 years have not yielded 3 quarters, and it is thought hardly 2½ quarters per acre. The average rental is about 30*s.* per acre, excluding the environs of Grantham, where the land lets for accommodation at from 3*l.* to 4*l.* per acre. The proportion of grazing and meadow land (not including Syston and Belton parks) is probably not more than one-eighth of the whole surface. The clay-lands were shallow-drained to some extent 20 or 30 years ago, which was certainly a marked improvement upon no-draining; but within the last few years a deeper drainage has been tried, tested, and preferred. The drains are now being cut not less than 3 or more than 4 feet deep, except where bogs or springs occur. Pipe-tiles are generally approved of. The labourers were much opposed to the deep-draining at first; but time and experience have informed them of their error, and it is also generally agreed that the stiffer the soil the closer ought to be the drains. The common distance between them is from 6 to 20 yards, according to the nature of the substratum. With a

clay bottom and rather mild soil on the top, drains 4 feet in depth, and at intervals of 12 yards, have been found to answer admirably well. There is about one-third of the clay-land now drained.

Mr. S. Hutchinson (agent to Earl Brownlow) has introduced a system of "air-drainage:" the parallel tile-drains, 3 feet in depth, empty into a covered outfall-drain, placed 6 inches lower, and receiving the eyes of all the other drains along the lowest side of the field. Another drain at the upper side of the field joins the other ends of the parallel drains, and is made to communicate with the open air by means of "respirators," or gratings, and by opening into the main drains or ditches. By means of the covered outfall drains many ditches are dispensed with, and the liabilities to choking from various causes are greatly avoided; whilst the air-drains effect a complete drying and purification of the sub-soil. The tenants, we believe, pay for the execution of the work, and the landlord furnishes the tiles; the whole being superintended by a proper person, who sees levels taken, trenches ploughed and dug, tiles laid, and everything completed in accordance with the principles and rules explained and recommended in Mr. Hutchinson's pamphlet.*

The last portion of the county remaining to be described before descending into the Fens, is, the broad tract of oolite hills between Grantham and Bourn, including the narrow band of Oxford clay and drift which borders the fen-land from Deeping nearly up to Lincoln. It is proposed to name this the *South-western district.* As there are few celebrated managers here, and nothing but plain common farming to be observed, this district is in general but little known. On the undulating oolite hills, covered in many localities with beds of drift, the soils may be classed, as regards their culture, into dry barley-land resting immediately on the limestone rock, and cold wet land. There is a large proportion of grass-land, especially upon the latter soil; much of it rough and rushy, and forming very inferior pasture. The fields are not large, and the fences are of a very different appearance to those of the newer inclosures on the Heath and Wolds. They are generally high, bushy, and straggling—by far too many, especially by the road-sides, being made up of briar, bramble, elder, hazel, and almost every wild shrub and plant *except* whitethorn. There are a vast number of woods, coppices, and covers, and some very extensive parks. Game is, therefore, an enemy to cultivation, which here occasions large losses by its ravages and depredations. The usual course of cropping on the clay land is—1. fallow; 2. wheat; 3. seeds;

* "Practical Instructions on the Drainage of Land," &c. Groombridge and Sons, London.

4. oats, or sometimes beans, and then wheat again. Dead fallowing is almost universally practised on the heavy land; but rape is sometimes grown, being fed off early, and the land sown with wheat. It is never left for seed. Only a wiry plant, however, is produced on this soil, and the surface is much too wet in rainy seasons to afford a suitable layer for sheep. In many seasons there is no occasion for a bare fallow, but much of the land that would grow coleseed is not sown, because of the uncertainty whether or not a dry time, and consequently a good layer, may ensue. On the dry land the rotation is—1. turnips; 2. barley; 3. seeds; 4. wheat. Swedes are partially grown, but more generally the white varieties of turnip; and the practice of sowing on ridges forms the exception, and not the rule, of the husbandry in this district. Artificial manures are rather extensively used upon the limestone soil, but not on the clays. The average produce per acre of wheat is about 3 quarters to 3½ quarters; barley, 5 quarters; and oats, 6 quarters; beans and peas do not occupy any considerable portion of the surface. The common rent is about 24*s.* or 25*s.* per acre, but, owing to the great diversity of soils, often rises to 30*s.* or upwards.

Both beasts and sheep are here bred to a considerable extent; the cattle generally of the Lincoln breed, and the sheep partly Lincoln and partly Leicester. There are several most important improvements to be recommended to the agriculturists in this district. Arthur Young states that the clay land, especially in the neighbourhood of Deeping, &c., was ploughed up into broad arched lands, but the furrows for 3, 4, or 5 yards wide were laid down to grass, and mown for hay, while the crowns of the ridges were under corn. "This management," says he, "is excellent, and much superior to having such miserable corn in these furrows from wetness, as is frequently seen on similar clay soil; the centres of the lands being high, are dry and fit for corn, and the furrows low and do well for grass." Since that time, however (1799), agriculture has progressed too far to bestow a commendation on such piece-meal cultivation, and has discovered a better mode of escaping from the evils of water in the land than that of endeavouring to lift one half of the surface above its wetness by depressing the other half, and subjecting it to a double degree of saturation and stagnancy. Much of the arable land is still in high-backed "lands," 8 or 10 yards in breadth; but in spite of this disposition of the surface, the clay continues difficult to manage in wet seasons, and the ploughing is performed by 3 horses in length with a man to hold and a boy to drive.

For excess of water and stubbornness of soil the remedy is the same—sub-soil drainage, which removes the former, and is found by that very process to change and ameliorate the latter.

The principal requisite here, then, is a complete drainage. The work has been commenced both with tile and stone—the proprietor furnishing tiles in the first case, or, when the latter material is employed, paying half the expense of "cutting out." But underdraining has not been done to a large extent on any of the soils, and the clays, on which it is needed as the very first step towards cultivation, are generally without any underdrains whatever. Here opens a wide scope for improvement: to the laying of adequate drains must be added the breaking of the hard subsoil by the iron tooth of the sub-pulverizer, a practice, we believe, entirely unknown in this district; and the land should be sweetened and lightened by applying lime, the stone for burning lying so near at hand, but rarely employed for manure. Another glaring defect in the management of this district is, that neither turnips nor artificial food are much used in the yards. Oil-cake is employed in most parts of the county as a substitute for roots drawn off the land, but here there is a general scarcity of either for the cattle in winter. Niggardliness in cattle-feeding is a false economy, and its effects are invariably felt in a diminished yield and a meaner sample; whereas, with a liberal outlay in the purchase of feeding stuffs for their stock, the farmers in this district might improve the heavy lands and enrich the light, so as to produce far greater crops than those on the weaker Heath-land, which they can now only rival.

South of Bourn, through Thurlby, &c., and north of Bourn and Edenham, are some extensive pasture lands, generally of good quality, but liable to "burn" in hot summers. The arable land brings good wheat and beans, and is generally well cultivated. To the south of Sleaford, through Scredington, Burton-Pedwardine, &c., upon the same clay, is an extensive arable district, managed upon the system of 4 crops and a dead fallow; and a considerable proportion of grazing land where both sheep and beasts are bred and fattened. Under tillage the land is difficult to work, and dead fallowing for wheat is universally practised. Along the edge of the Witham Fens the light sand and gravel are found covering a large portion of the clay, and not more than one-sixth part of the land is under grass. The four-field system, viz., 1. turnips, 2. barley, 3. seeds, 4. wheat, is chiefly observed upon the sand, whilst beans and wheat form the principal crops on the clay. Very few swedes are grown, perhaps not more than one-fifteenth of the whole turnip crop: the average produce upon this small quantity may be placed at 18 tons per acre. The principal sorts of turnips grown are the white and purple-top turnips, which yield good food and an abundance of it—thus excelling both in weight and quantity.

The following scale conveys at a glance the requisite informa-

tion respecting the average produce per acre of each kind of land,—

Tract of Soil.	Wheat.	Barley.	Oats.	Beans.
	Qrs.	Qrs.	Qrs.	Qrs.
Clay land . . .	$2\frac{1}{2}$	..	..	4
Sand land . . .	4	5	7	..

The *Fens of South Lincolnshire* have already occupied a prominent place in the report on the Great Level, published in the Journal in 1847, and therefore a lengthened statement here of the varied rotations and peculiarities of husbandry to be found in these fens would be only a repetition of the same circumstances: a few observations under the heads "Peat" and "Alluvium" will therefore suffice.

Peat.—The chief process upon which all success in the tillage of the black land formerly depended was paring and burning; and because the earth was of a nature to be easily consumed by the fire, it was unsparingly cut and dissolved into ash and air. As drainage became improved, the peat losing its moisture, contracted itself, and occupied less space than before, so that from these causes the whole surface was found to subside, and approach nearer to the subjacent clay. Some years ago the clay could not be found in most parts of Deeping Fen, unless by sinking pits or trenches, and the ditch bottoms were all moor. Now, however, the clay is frequently ploughed up, and in the bottom of the ditches is found the subterranean timber which underlies the moor, resting upon the clay. So troublesome are these trees, in consequence of the lowering of the surface (about 2 feet in 25 years), that, when fallowing, the ploughs have each a wooden pin to connect the heel-tree with the plough-cock, and directly the share catches a tree the pin breaks, thus letting go the team without breaking the implement. The ploughman carries a bundle of reeds (of which thousands grow in the ditches) with him, and when he is stopped in this manner he sticks down a reed as a mark for the digger who follows him to take up the wood. Immense quantities of these black tree roots and stems are dug up every summer in Deeping Fen. Cultivation still further compresses and concentrates the loose mould, until it is found in some parts of the Fens that by far too much has been burnt away, and that there is a danger of the soil becoming too stiff and clayey. Paring and burning was superseded by the plan of intermingling the peat and its heavier sub-soil of clay, silt, or sand. This has converted a light, loose, and scanty yielding soil into a firm and most productive soil, capable of bearing the heaviest

crops of rape, wheat, or oats. Most of the peat fens have been clayed, many parts twice, but in some districts this has yet to be done. In Bourn Fen the peat is clayed on one estate with excellent effect, whilst on land adjoining the proprietor does not allow his tenants to "cut up" the soil—they may plough as deeply as they please, but if they trench, more rent is instantly demanded. Peat land is subject to "honey-comb," or contract when dried by frost, the upper crust of earth pinching the young wheats and loosening them from the land. Much cropping is injured in this way, and the remedy doubtless is a better district drainage, and then a complete hollow drainage. Underdraining is becoming a common practice in many parts of the fens, but it is yet done only by the more enterprising farmers, and cannot be looked upon as a main point in the general management. Oil-cake for cattle in the yards, and bones for the green crop, are universal items of fen husbandry. There is one manure which is hardly ever seen here, viz., lime; it is precisely the chemical agent required, as its action is to neutralize the acid substances formed so rapidly in the peat, and thus to preserve the soil in a condition for nourishing the tenderest plants. The great obstacle to the use of lime here is the cost of obtaining it; but if the distance of the limestone from even the western Fens, next the hills, be too great for carting with profit, the railways have now extended their firm smooth tracks of iron across the softest and most miry portions of the level, and can convey lime with cheapness and expedition even into those localities which are furthest from the quarries. Both lime, chalk, and marl, may now be carried in abundance by rail from the neighbouring uplands over East Fen, the whole line of fen from Lincoln to Boston, and across Deeping Fen, and the marsh lands between it and Boston. Besides these lines of swift transit there are the slower but readier roads of water; all the larger drains and rivers are navigated with cargoes of corn and coal, and being ramified through every part of the fens, might convey enriching earths from various railway stations, and deliver at any desired point. Convenience for supply is ready and complete, and it remains now for the farmers and proprietors to decide whether it be desirable and profitable to improve the soil by returning these manures in the same boats or trucks which take their produce to market.

The peat soil is not difficult to work, but is peculiarly infested with "twitch" (or couch); the light yet rich earth forms a fine matrix for the growth of its long penetrating fibres, and great labour is necessary in constantly eradicating it. Field mice undermine the land and devour immense quantities of cropping. The wireworm also revels here, as neither pressing with the roller nor

trampling with the flock can give a solidity to the ground sufficient to check its ravages. Young wheats are much blown and destroyed, and the best preventive hitherto is Crosskill's clod-crusher, which astonishingly compresses the soil and improves the crop. The treading of sheep is indispensable to tillage in this district, and though ill adapted for turnip husbandry, the peat brings an enormous bulk of green food in the shape of coleseed (or rape). The mode of cultivating this plant will be treated of under a separate head. Coleseed, wheat, oats, and seeds, are the principal crops; and the land is manured frequently in consequence of its moisture and porosity. Deeping Fen has acquired celebrity for its excellent soil and its enterprising managers. Nearly one-half is sown with wheat, the remainder being coleseed, clover and grass seeds, and oats. Generally speaking, the various artificial aids are plentifully employed in every department of feeding and manuring, neatness is the order of the farmsteads and fences, great expense is laid out in the cleaning and weeding of the soil and crops, and the total result is a reward of large yields of corn and a quick growth of meat. Travelling northwards, and passing Thurlby Fen, a deep peat-earth, mostly under grass, which is rarely the case on the peat fens, Bourn Fen, and other districts, where the course of 1. coleseed, 2. oats, 3. wheat, 4. seeds, 5. wheat, is usually followed; the soil becomes partly alluvial and loamy, and a larger breadth of beans are grown. Along the peaty tract of the Western Witham Fens, the course is about equally proportioned into a 4, 5, or 6 field system, according to the choice of the occupiers, the latter being 1. coleseed, 2. wheat, 3. seeds, 4. wheat, 5. oats, 6. wheat. There is scarcely any old pasture now left in these fens. The average produce is of wheat 4½ qrs., barley 6 qrs., and oats 8 qrs. per acre. Upon the heavy soils on the opposite side of the river Witham the rotation is generally as follows—1. turnips, 2. barley or oats, 3. seeds, 4. oats or beans, 5. wheat. In the East Fen all the peat lands have been clayed, and a large portion several times. Underdraining is being practised to some extent, the pipes being laid in the clay. The courses of cropping are very various, but the best farmers take three-fifths of white corn. Many beasts are wintered with oilcake and straw, and the sheep are grazed on the seeds and fattened on the cole. Large quantities of bones and "Boston manure," &c., are applied to the land for the production of green crops; and the district is generally under thriving management. Its bulky crops and abundant stock are what drainage and culture have substituted for a wilderness of reeds and wild-fowl. The stranger may now find all the various operations of husbandry going on just as in other superior districts; but before the drainage, cultivation was impossible, and Young mentions

"an ingenious and very simple tool in use in East Fen," viz., a sledge for going on the ice. "It is a small frame," he says, "that slides on four horse-bones, the driver pushing himself forward with a pitchfork." The agriculturists of this district flatter themselves that they can now exhibit objects of far greater interest to the attention of a reporter; and certainly a more lengthened statement would have been here given had not a previous paper in the Journal been devoted to that purpose.

Alluvium.—Wildmore and West Fens were similar tracts of sedge and pool, but are now in tillage, producing large crops. Wheat, oats, and beans, are grown upon the clay, and wheat, oats, and barley, on the sandy land; the intermediate crops being seeds, turnips, and cole. About half the seeds are grazed by long-wool sheep, the rest being mown for hay. Underdrainage has been extensively carried on, but much land yet remains to be made friable by its influence. The buildings are pretty good, the hedges neat, the stock well fed, and there is every appearance of superior cultivation. Holland Fen produces nearly every variety of cropping, the general largeness of the yields arising from the natural richness of the soil and the ample application of oilcake yard-manure. Few portable manures are here used, but they would doubtless prove highly advantageous. The general outfall being good, a perfect system of hollow-draining might be established; little, however, has yet been completed in an effectual manner. In the parishes on the coast north-east of Boston are three different kinds of land and management. The newer marsh lands are arable and pasture, chiefly the former; the grass is well adapted for feeding horses; and the sheep upon it produce a great quantity of meat and fleeces of great weight. The ploughed land is of the best quality, bringing heavy crops of wheat, oats, and beans. More inland is the higher ground on which the villages stand, and here is some of the luxuriant grazing land, for which Lincolnshire is noted. The herbage is thick, forming a sward of a soft and carpet-like texture, sometimes swelling into tufts, but generally even and smooth, and always soft to the feet. It is in small inclosures, and neither the fences nor ditches are kept in good order. The arable land is not generally well managed, though considerable improvements have been made of late years. The principal care of the farmer was to manage his live stock and keep his pastures in order, whilst the working of his arable land was neglected, and the grass received more than a fair proportion of the weak manure from the yard and stable. The practice of taking two or three corn crops and a fallow has not been forgotten, and but little clover or seeds are sown. There are instances, however, of more judicious management—root crops and coleseed are grown, oilcake

is given to the beasts in winter, and underdraining has been commenced. Between this tract and the fen is a line of meadow land, called "The Ings;" a considerable portion is mown, and the hay partly consumed on the land, the remainder carried to the yards in the district just noticed. The drainage so improved this low ground that much has been brought under the plough, and it now produces good oats, wheat, turnips, and coleseed. The superior grazing land extends southward of Boston, through Kirton, Algarkirk, Sutterton, Wigtoft, Gosberton, &c. The beasts fed are generally of the Lincoln breed, though both Scotch and Hereford cattle are sometimes purchased. They are bought in spring, usually at Boston May Fair, and sold fat in autumn; the best land feeding a bullock an acre without any supply of linseed cake. The sheep pastures will often carry 8 or 9 sheep per acre, and they fatten the animals without the assistance of other green or dry food to finish them off. In the parishes of Kirton, Fosdike, &c., a considerable amount has been underdrained both with tiles, sod-wedges, and the mole plough, and with advantageous results; the removal of the moisture improving the quality of the herbage, and rendering the ground much more healthy for the stock. One individual, an extensive grazier and excellent manager, has used large quantities of lime upon his pastures, and its effects in sweetening and increasing the herbage were most satisfactory. Great care, however, was required in the application, as a strong dose of quick-lime would destroy instead of stimulating the herbage. The arable land is very productive in corn, pulse, and root crops, and large breadths have been broken up for woad, mustard, and chicory.

Red mustard is very extensively cultivated in the south-eastern alluvial district, and the seed sold to be manufactured for domestic uses. There are several woad establishments in this country, though only upon the very richest land (as woad returns nothing to the soil), broken up from grass on purpose for growing this plant. The principal points in the culture are—drilling the seed in March in rows 8 or 9 inches apart; hoeing-out when the plants are about 4 inches high, so as to leave them 6 inches distant from each other; thinning and hand-weeding twice; "cropping" or gathering by hand when 8 inches high, *i. e.*, a little before Michaelmas, and hoeing directly after. The leaves may be thus plucked 2 or 3 times in succession, and are crushed by the mill (in their green state) into a pulp. This is allowed to drain, then made up into balls, and dried for several days in open sheds built for the purpose. During the winter the fermentative process is carried on: the mill grinds the hardened balls into powder, and "couching" then begins, the powder being watered daily for several weeks, ferments; and when this is com-

pleted is packed in barrels ready for sale. Produce, perhaps 2 or 3 tons per acre. In the parish of Algarkirk is a large chicory establishment, and there are others near Spalding and in the parish of Holbeach. As with woad, so with this crop, the land must be remarkably clean, as all weeds, especially *chickenweed,* are excessively detrimental to its growth. The seed is drilled in 9 to 12-inch rows, 3 or 4 lbs. per acre, in the middle of May. The plants are usually singled out, at intervals of 8 inches, and the land carefully hoed. The roots are taken up in October, November, &c., with strong double-pronged iron forks, about 14 inches in the blades. Ploughing them up at 12-inch depth is sometimes practised, and is perhaps the better method, as in digging the roots are apt to break off at 8 or 9-inch lengths, unless pulled at the top whilst the fork is "prizing" below. The green tops are cut off, the roots washed clean, cut into small pieces, usually by a turnip-cutter, and dried in a kiln. The chicory is then marketable, and is sold to grocers, who roast it like coffee. One to 1¼ tons (when dried) is an average crop. The leaves are devoured with great avidity by cattle, but are most frequently "ploughed in." They have been also used to adulterate woad.

South-east of Spalding, through Moulton, Holbeach, Long Sutton, &c., the fine pasture lands continue. The parishes are of great length north and south, but of narrow breadth, extending north of the villages and towns into fertile marshes three-fourths under the plough, and southward for two or three miles (of exceedingly fine land both for grazing and tillage) into more tenacious clay fens. Peculiar value belongs to certain spots, and the grazing farms of this first quality are known throughout the whole district by their names, as (for instance) the "four-scores," and "the hundred-acre farm," &c.; and many of the better fields are famed as "the hill piece," "the doles," "the Jew's meadows," &c. The grass-land in the Marsh causes scouring in young stock, and great injury is occasioned by the saltness of the water in the creeks and ditches; a considerable quantity of sheep, however, are there bred. The richer lands in the central portions of South Holland are exactly suited as a change for the stock; and whilst the Marsh lands will feed sheep and heifers, these will fatten bullocks of the largest size.

May is the usual month for stocking the grass lands. The sheep pastures have a proportion of one young steer to 12 sheep, the number per acre depending upon the quality and condition of the field. The bullock-lands have one horse to every 12 beasts. The head of stock should be regulated in such a manner as to keep the sheep land comparatively bare, but the cattle ought to have a good bite: rank herbage is deleterious to the health of a sheep, but an ox requires a plentiful supply of food, that he may

quickly feed, and have ample time to ruminate. An old grazing rule is, "grass should be 24 hours old for a sheep, and 12 days for a bullock." The richer spots produce tufts of coarse grass; these must be mown, a small portion daily, so that the cattle may eat the grass as it decays; if left, they become so rank and sour that nothing will touch them. The chief attention of the grazier, apart from a careful watching of the progress and healthiness of the animals, is devoted in the hot summer months to the stocking of his fields. In some seasons the grass grows with such vigour as to lessen its nutritious properties, and the pastures must be crowded with all the stock they can possibly carry. Toward the latter end of the summer a gradual thinning must take place, and great care is needful in order to keep the pastures good. Fatting beasts and sheep become then fit for market, and this affords facilities for the proper management of the lands. Thistles are in general carefully destroyed in this district; when very numerous they are mown, but the most common method is chopping with the spud, and in a wet season drawing up with "tweezers." The droppings of the animals are carefully spread, so as not to destroy the grass. The proportion of hay is not great; the meadows are "laid in" in April and May, and mown in June and July; the eddishes furnish a valuable pasturage in the autumn for easing the grazing lands as they fail. These meadows occasionally receive a top-dressing of manure in the winter, which is well brushed in. After harvest the stubbles afford a rest for the grass-lands, for in spite of all the weeding the arable land produces much grass and weeds among the crops, and when they are removed both sheep and pigs over-run the fields to eat up what is called "the shack." As the winter approaches, the remaining store cattle are taken to the yards, and the sheep not put upon coleseed or turnips are distributed over the pastures at the rate of one per acre. Very few hedges are to be seen in the district south of the towns, but the Marshes have both hedges and ditches. The absence of hedges occasions the loss of many sheep by drowning, and in winter the sheep frequently cross the ice of the ditches and wander for miles over the country. There are but few trees, and most of the bullock-pastures have stout posts erected for the cattle to rub against. Underdraining has not yet become general, but it has effected great benefits upon wet and rushy pieces of grass. It is greatly needed, for the pastures abound in low places and long hollows, which the rain always fills with water. The arable fen clay is difficult to work, always either miry with wet, or hard and cracked by sudden drying; when the season is favourable it produces fine crops of wheat, oats, beans, and red mustard. A deep subsoil drainage and a deep pulverization, the grand requisites of this district, are

entirely unattempted on an efficient scale. On the friable soil of the Marshes large crops are grown, both of turnips, coleseed, oats, wheat, peas, beans, and potatoes. In some localities bare fallows are still indulged in, and there is generally a want of liberality in the employment of artificial food for stock. While many convenient farmsteads are to be met with, the farm-buildings in general (especially on the smaller holdings) are of a miserable description—the yards totally uncovered by sheds for the cattle, the manure exposed (in addition) to the drippings of the barn and hovel roofs, the stables badly floored and drained, and owing to the age of the buildings (many now in a dilapidated state) there is both a want of arrangment and a scarcity of convenient feeding and root-houses. On several properties, as Guy's Hospital estate near the mouth of the Nene, considerable improvements have been made by supplying these defects; but, as a general rule, the landowners are inattentive to them. The hedges and ditches are badly kept, very few of the former being trimmed by the hook, and the latter are cleared once a year from the grass which chokes them, though the more urgent duty of widening and deepening them is too often neglected. The fen dikes produce large crops of tall and stout reeds, which are cut green in summer and used with great advantage for covering down stacks. The roads are bad in wet weather, and from this cause the farmsteads often present a dirty and slovenly appearance. The ploughing, scarifying, and general tillage of the land is good, though it is more frequently broken by harrows than torn up by scufflers and drags; and the "tilting" or shallow working of the stubble-fields is universal. Ridging is extensively practised for the green crops, but no large amount of bones or purchased manure is sown. Hollow-draining has been done to some extent with thorns or wood, and a smaller portion with tiles. The holdings are usually small, and the fields in a similar proportion. In the large parish of Holbeach the farms are more extensive, varying from 200 to 1000 acres. The ownership of South Holland is remarkably subdivided between a great number of small proprietors; and as a whole estate is often comprised in 20 or 30 acres of land, with a cottage, barn, hovel, and small yard upon it, an endless diversity of system and management is practised by the occupiers. There are many well-managed farms; but, upon the whole, the upland farmer who may have had an exalted opinion of this district will find that it is more remarkable for the productiveness of its soil than for the able manner in which it is cultivated.*

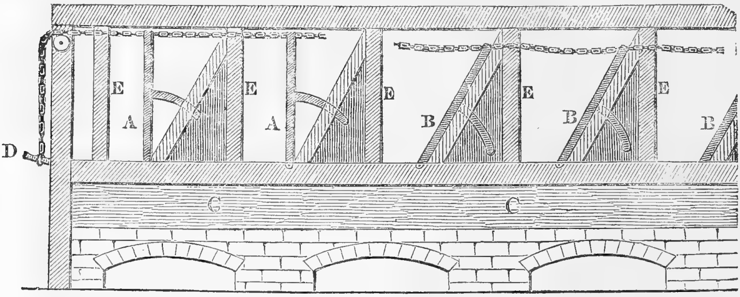
* The customary Tenant-right which prevails throughout the lowland district need not be specially dwelt upon: at Lady-day the outgoing tenant is allowed for the seed and labour of the crops sown, and for the spring tillage that has been done; fodder and

4. *The management of the farm-yard, with the advantages and disadvantages of putting up the ricks at one central homestead.*

Speaking of homesteads in the aggregate, and considering the number of small freeholds, it may be said that the Lincolnshire farm-yards and buildings cannot boast of their convenience of arrangement or superiority of construction. The barns are generally small, the stables often uncomfortable or ill-ventilated, the roofs unspouted, and the strawyard so situated as to lose immense quantities of liquid manure by soakage and drainage into brooks or ponds. But deficient as they are, compared with what they might be, we believe them to be of a better class than those of most other counties. The yards have generally a bullock-hovel and barn, &c., to shelter them on the north, walls round the remaining sides, and divisions of bar-fencing or long faggots. The beasts are bedded and fed with straw carried daily or as required from the stack-yard, and it is common, when thrashing from the barn, to stack the straw in a corner of the yard. It is also usual during the winter to employ one or two men in the barn, who thrash oats or beans by flail, and fodder the cattle with the straw. The number of beasts fattened on the light lands is comparatively small, and the feeding hovels are not very extensive. Two animals tied (or rather chained) in each stall, with low mangers for food, a trough or tubs for water, and a "walk" or passage along the front of the stalls, is the general order of the hovels. The back of the stalls consists of a row of posts or pillars instead of a wall, a thorn fencing generally dividing the hovel from the yard. The beasts here are supplied with hay, oilcake, and turnips, and their excrement is daily thrown over the fence into the yard. This will be most frequently found to be the character of the farm-yards and hovels, this county having so many on a small scale; but upon visiting the larger farmsteads are invariably seen open sheds around the straw-yards, root, cake, and chaff houses, drinking troughs supplied by pipes and cisterns, and yards divided by walls or sheds. Many have a square space fenced off in the centre of the yards for stacking straw, which is then conveniently placed for replenishing them; and occasionally a straw barn is to be met with in a similar situation. In the northern parts of the county great efforts have been made in the improvement of the homesteads, and in providing better shelter for the cattle and protection to the manure, but much yet remains to be done in this respect. Box-feeding is very sparingly adopted in Lincolnshire, although boiled linseed mixed with chaff is extensively used for food in

keeping are taken at a valuation. Within the last few years it has become usual to make a full allowance for all the labour expended upon a dead fallow.

some districts.* The yard beasts generally eat their cake from cribs, placed in different parts of the yard; but where there is an open shed a manger is provided for the purpose. It is now becoming customary to have a framework upon the front of this trough, so that each animal is prevented by a wooden upright on each side his head from jostling his neighbours and getting more than his share of the food. In the premises at Hareby is a neat contrivance for tethering the cattle, appended to the mangers along one side of each yard, each manger being large enough for 10 beasts. The subjoined diagram will show its action:—



B B B are iron levers, which can be set upright or allowed to fall in a slanting position by means of a chain connecting their upper ends. The cattle put in their heads (in order to eat out of the manger C C) when the levers are in the position shown at B B B, and a sudden pull of the chain by the handle D brings all the levers into the posture shown at A, thus holding the necks of the animals between the irons and the posts E E E E E.

The Lincolnshire method of feeding horses is to give them cut oat-sheaves nearly all the year round, and sometimes ½ a peck of beans each as well; and when this is not done they have a peck of oats each per day and sometimes a few old beans. They eat clover-hay in the yard during the winter and grass in the fields in summer, tares (or vetches) also forming a part of their spring provender. In the newer farm premises each stable is made to accommodate 4 horses, and has a chaff-house, with cutter, &c., and a gear-house to match, whilst one or 2 loose boxes are provided as a "hospital."

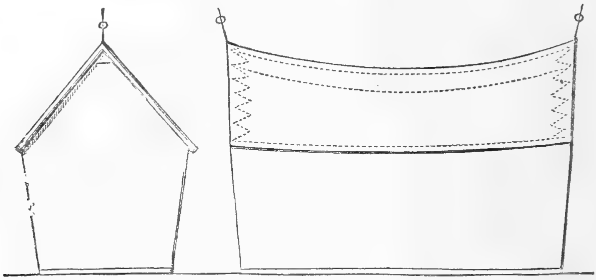
Steaming and boiling food for pigs are universally practised,

* This is not apparently a modern innovation: at the close of the last century it seems to have been tried in Lincolnshire. Young says, "Mr. Thorpe, at Owersby, has a bullock-house; the beasts may be loose or tied. Dearness of oil-cake induced him to substitute linseed, boiled and mixed with barley-meal—2 quarters of barley, 4 bushels of linseed, and mixed to give cold in the form of a jelly. This quantity will go as far as half a ton of cakes, costing less. Half a peck of linseed is boiled in 4 gallons of water."

and many animals (of a large breed) are made into pork. One farmer lately sold at Boston 1000 stones of pork to one butcher, and had upwards of forty fat hogs at one homestead, weighing 35 stones apiece. Barley meal, wheat offal, and potatoes are the general food, but steamed turnips and mangolds have been tried with success. A cheap apparatus for steaming is made by fitting a tin head and pipe to the copper used for boiling linseed, &c. The steaming-pans, consisting of two liquor casks ("brandy pieces") furnished with lids, and hung by iron bearings (mid-way up their sides) upon posts, so as to turn over for emptying. One steamer is cooking its contents while the other is being emptied and filled. The whole may be obtained for less than 2*l.*

In the management of manure nothing peculiar is to be noticed; there are few tanks or liquid-manure carts, and, with the exception of a farmyard at Revesby, probably no instance of the dung being preserved under cover. Near most farmsteads is a muck-heap—exposed to all the abstractive influences of sun, wind, and shower—which is augmented from time to time by fresh manure from the yards. The manure, however, always accumulates many feet in thickness in the yards, and is "turned over" in the spring, about 6 weeks before required for use, being then in its best state (according to Davy) for forcing vegetation. As a general rule better care is taken of this article, and the farmyards are kept cleaner and neater, where the buildings are good; carelessness and waste appertaining chiefly to the inferior premises. A rick-yard is an indispensable portion of a farmstead, but in the elevated districts of this county a large proportion of the corn is stacked in the fields. Upon the Wolds this practice appears to have been lately on the increase as far as regards wheat—the barley being generally carried home. One *advantage* seems to be the saving of time in harvest. The corn ripening a week or two backwarder than over the generality of the county, and the weather often turning into sudden wets, a saving of two or three days becomes precious. The wold fields and farms are so large that a central homestead must necessarily be at a great distance from much of the cropping, and therefore the amount of time gained by "stacking abroad" is very considerable. In the low country the badness of the roads effectually prevents this system from being followed; the corn could not be carted home at any required time to be thrashed, and if thrashed in the field and the straw left there, a very great inconvenience and loss to the farm-yard would obviously arise. On the chalk-hills, however, the roads (being chalked and then coated with flint) are passable all the year round, and the barns generally afford larger accommodation for mowing and thrashing. Greater safety in case of fire is a great consideration; it being common, on the Cliff and other

districts, to see the corn stacked in all parts of the farm and the ricks set widely apart. Insurance Offices have, in some instances, requested that this precaution and care should be taken. The principal *disadvantages* are as follows: first, the inconvenience of having to break off the teams from their work upon the land, to lead home corn whenever straw is required for the yards: second, the increase of expense in carriage—the crop has to be loaded, carried, and emptied twice instead of once; a convenience may be felt in harvest although roads are then good, but a greater inconvenience occurs by having to lead the cropping when the roads are often in their worst condition, and either way the whole weight has ultimately to be carried the same distance; straw for thatching must be taken from the yard to the fields in harvest time; and further, if the ricks be thrashed in the field (in fair weather), the straw has to be led home and the corn also before it is winnowed, and if taken home to be thrashed, the whole bulk has to be unloaded, stacked in the barn, and again thrown off when the machine is at work. Farmers must use their own judgment as to which is the better plan, and most adapted to their respective holdings. Few of the Lincolnshire ricks are built upon frames—a layer of straw being the usual "steddle" or foundation. Both round stacks (or "cobs") and square stacks, in a connected row (or "joints"), are common, varying much in figure and magnitude in different districts, and often carried up to a great altitude by the assistance of a platform or "stage." The most prevalent shape is that with right lines forming a section of its roof and walls, viz. the following:—



In some parts of North Lincolnshire the subjoined (fig. 1) is the section of either a round or long stack, the roof, by the slanting position of the sheaves, being well calculated to shoot off the rain.

The most common form on the Wolds is shown in fig. 2. Having the roof thus drawn in, though as many square yards of thatch are needed as on the square stacks, the same bulk of

corn is covered with less in the roof; and the thatch is much safer from wind than upon the ricks with high-pointed gables.

In the Isle of Axholme is found another type (fig. 3), partaking probably more of the picturesque than the profitable.

Fig. 1.

Fig. 2.

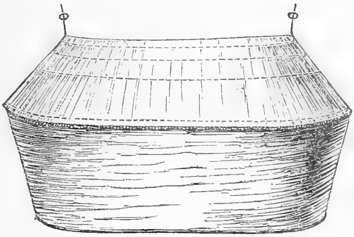


Fig. 3.

5. *The suitability or otherwise of the present Long-woolled breed of Sheep to the ranges of light Turnip Land in the County.*

In considering the next subject proposed by the Society, it will be advisable to state first, in a few words, what the Lincolnshire sheep really are. The old Lincolnshire long-wools were ungainly animals, with a carcass long and thin, legs thick and rough, bones large, pelts thick; and though attaining to a great weight they were a very long time in arriving at maturity; in fact their chief merit was their wool, from 8 to 16 inches long, and weighing from 8 to 14 lbs. per fleece; and this wool formerly made the breed profitable to the lowland graziers although covering a slow-feeding, coarse-grained carcass of mutton. Upwards of 50 years ago, when Young wrote his 'Survey,' the New Leicesters were spreading very rapidly over the county, probably faster than they had done (with one or two exceptions) in any other, driving out the Lincolns from the poorer lands and improving them by crossing. "The true Lincoln," he says, "is a larger sheep and with a longer wool, and therefore demands better pasturage; where it finds such, there the old breed remains. Upon inferior land the Leicester establishes itself, from the necessity of having smaller size and shorter wool." At the present time the pure old-fashioned Lincolns are scarcely to be found, except in some few places in the south-eastern lowland and the rich eastern marshes. The improved Lincoln and Leicester sheep universally prevail, varying widely, however, in different districts; and while perusing the following characteristics, the reader must remember that prejudice for one's own is as firmly rooted in this as in many other counties. The larger breeds chiefly occupy the south-eastern quarter of the county, and are known as "the Lincolnshire Long-wools," in contradistinction to the Cotswold and im-

proved Oxfordshire breeds. They partake largely of the peculiarities of both Cotswold and Leicester, having the expansion of frame and nobility of appearance of the one, combined in a great degree with the quality of flesh, compactness of form, beauty of countenance, lightness of offal, and inclination to fatten of the other; but they far exceed either in the weight of their wool. They are usually kept until 27 to 33 months' old, when their weight is from 28 lbs. to 72 lbs. per quarter; and the two clips of wool weigh together about 20 to 25 lbs.* Under good management this wool is of a quality which rarely fails of obtaining a price equal to that of the lighter long-wools, or even pure Leicesters; and there is, therefore, perhaps no breed that can equal this in rapidity of growth and propensity to fatten under a fleece so weighty and valuable. The more celebrated breeders of rams of this variety are Messrs. Kirkham, Benniworth, Topham, Clarke, &c.† In the midland and south-western parts of Lincolnshire the sheep are more closely allied to the true-bred Leicesters (the proportion of "blood" being estimated at three parts Leicester to one of old Lincoln), and are very compact and well formed, with fine and good countenances, and rather close-set but beautiful wool. They can generally be fed off at the age of 18 to 27 months, and are noted for their large proportion of lean meat; if kept longer it is for the purpose of taking the fleece—the two fleeces weighing together about 17 lbs., and the carcass about 35 lbs. per quarter on an average.‡ The more eminent breeders of this kind are Messrs. Casswell, Brice, Clarke, Gilliatt, Chaplin, Cooke, Smith, &c. In the northern and north-eastern parts of the county about one-fifth of the sheep are pure Leicesters, of the superior breed sometimes called improved Leicester; Messrs. Abraham, Skipworth, Torr, Dudding, &c., are a few of the favourite breeders. The remaining four-fifths are descended from the original large Lincolnshire sheep, crossed latterly with Leicester rams—being thus neither too coarse nor too delicate, uniting size with quality, and having heavier fleeces though of coarser quality than those of the unmixed Leicesters. These sheep are admirably suited to the

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* Some instances of extraordinary weight may be stated:—A wether sheep killed in Holbeach Marsh in 1844 weighed 72½ lbs. per quarter; 10 wethers were produced by one farmer, in the same locality and at the same time, averaging upwards of 52 lbs. per quarter each; and an *ewe* from Long Sutton Marsh, exhibited at the Smithfield Club Cattle Show in 1846, weighed when dead 65½ lbs. per quarter, or 262 lbs. the whole carcass.

† The writer has hitherto avoided personal references: under this head, however, names are of great consequence, and *some* of the more noted breeders of sheep are here mentioned.

‡ A breeder in the neighbourhood of Grantham showed a shearling sheep (some time ago) which clipped 17 lbs. of wool, and weighed 22 stones,—being one out of an "even" lot of 27.

light land districts; and the breeders keep up their breed by selecting different rams—sometimes for wool, sometimes for symmetry, mutton, &c. &c. On the Cliff the first cross is considered the best, viz. the produce of a large heavy-woolled ewe that has been put to a good pure Leicester ram.

The question of their suitability implies a comparison: are they better adapted to the Wolds, Cliff, Heath, &c., than any other breed would be? The only varieties which can come into competition with these Long-wools, are, we should think, the pure Leicester and the South Down. If the Lincolnshire uplands resembled the wide open downs and bleak uncultivated sheep-walks of more southern counties, and the system of driving and folding were practised or required, then the South Downs, being better travellers, would undoubtedly be a desirable breed. The principal purpose, however, for which sheep are kept on these lands, is to eat off the turnips, and the large breed does remarkably well for folding after the Lincolnshire custom; that is, the lambs occupy the foremost inclosure of hurdles, followed by the older sheep, both being supplied with corn or cake and the turnips (sliced) in troughs, and the folds are moved forward daily. The fine and thickly-set wool of the South Down sheep may be well calculated to resist the keen blasts of the hills; but the Lincolnshire breed (like the Cotswolds on their elevated lands) are also hardy, possessing heavy, warm, well-set fleeces; and it must be borne in mind that the smaller kind of long-wools are native inhabitants of these ranges. If the question were—Which of these two breeds will thrive the best upon hard fare? the reply might have been given in favour of the Down; but the "light turnip lands" afford an abundance of good provender and a dry layer, and the question is therefore of a different nature. The South Downs have not been fully tried, but general opinion declares against them. A cross between Leicester ewes and Down rams has been attempted in some localities, not with the idea of its ever becoming general but merely for special purposes, the produce having been sold as "fat lamb"—a practice incapable of large extension in these breeding districts. The Leicester has certainly proved the most generally useful of all breeds, both for grazing in all but mountainous regions and for improving other kinds of sheep; and if aptitude to fatten quickly on the kinds of food, and in the climate and situation of the Lincolnshire highlands, were the only circumstance to be taken into account, without doubt the strong (or improved) Leicester would be most suitable and remunerative. As a proof of this, the breeders of large sheep themselves allow, that whenever farmers make off their own flock instead of selling their lamb-hogs to feeders, they choose a small breed and keep close to the pure Leicesters. Another consideration, however,

presents itself; the light lands being excellent for breeding, and the lower parts of the county ill adapted for that purpose, the former have become a vast repository for supplying the rich grazing grounds with sheep. On the fat pastures are required large animals with plenty of wool, and thus the upland farmers breed heavy sheep in order to suit their customers. A large frame and a speedy growth are indispensable to the production of great lamb-hogs, and a pen of small hogs would stand a poor chance of sale at the large spring fairs of Lincoln, Boston, and Caistor, &c., which form the principal market for them. By the above-mentioned cross, then, are secured a great natural size, quick feeding properties, and warm fleeces; in short, a breed exactly suited to the soils, the climate, and the market. Experience (no bad criterion) attests the truthfulness of this inference—many instances of extraordinary growth and maturity being annually produced; and the names of breeders who yearly exhibit at Boston and Lincoln fairs pens of hoggets weighing from 25 lbs. to 32 lbs. per quarter each, are well known in most parts of the county.

6. *The desirableness or otherwise of increasing the proportion of Swedes in the Turnip Crop for Spring consumption.*

Upon the Marsh lands and richer soils capable of producing good swedes, they form half the root crop, and particular care is bestowed upon the preparation of the land, the manuring, and seeding, as on this portion of that crop the stock are mainly dependent for their spring food; and this variety of turnip is believed to yield a much greater weight per acre, of better quality, and safer from the attacks of frost than any other. Swedes have thoroughly established themselves as the most prolific, wholesome, and hardy kind of turnips on good land; and where they are scantily cultivated the reason may be looked for in the inferiority of the soil or some other physical peculiarity of the neighbourhood. Upon an average of the different districts of the county, excluding the oolite and chalk hills where their growth is very limited, probably not more than one-fifth of the root-crop is swedes. Wherever they can be grown with advantage the proportion has increased of late years, a fact which indicates that they require superior management—the breadth sown having enlarged with the general progress of husbandry. Being much more relished by the *fly* than common varieties, swedes must be forced in their early growth by artificial stimulants and compost manures;* but such is the excellence of this root, that, under

* Perhaps the cheapest and most useful of all composts is the following:—2 bushels

proper management, the most harsh and infertile clays will not fail to develope it into maturity and abundance. From these considerations it appears advantageous upon most lands to devote a large proportion of the green crop to the growth of swedes; and as, from the information collected, this does not seem to be generally done in Lincolnshire, it follows that in the majority of districts an increase of the proportion would be desirable. In the oolite district south of the Heath, swedish turnips are only partially grown; but on the better soils near Grantham the proportion is more than one-fourth, the remainder of the crop being green and white top turnips. Over the central district of the county, with the exception of the clay land, which contains a fair proportion, they are seldom grown, whites being the chief sort. Scarcely any are to be found in the flat district east of the Wolds, except adjoining the great south-eastern tract, where it is usual to sow white turnips on the loamy and lighter soils and swedes on the stronger lands. In the marshes bordering the Wash they form the principal roots grown, and therefore the chief improvement to be made here is in the bulk per acre rather than the acres per farm. In the north-western district the proportion of swedes is not great to the whole number of acres of turnips sown: on the best lands there are some excellent pieces, but on the rest two hindrances exist—they are peculiarly exposed to the attacks of game, and demand more "stimulus" than the occupiers generally are able to apply; and they require to be sown before the clay land can be got ready, the lateness of the harvest affording no opportunity for working it in the previous autumn. Upon the Cliff the green top yellow (also known as "Hanoverian," or "yellow bullock") is the sort used for spring feeding; although the swede will exhibit a far more diminutive per centage of rotten bulbs after a severe blast, and produce a sounder and greater amount of food. The latter is not discarded on account of the soil, for three-fourths of the land between Lincoln and Brigg would grow swedes remarkably well: the main objection seems to rest upon the preference given to this variety by the fly. Now a newly-sown field of grain, when all the crops in the neighbourhood have been long above-ground, is peculiarly subject to the robberies of rooks; and in a similar way an isolated patch of choice provender will inevitably suffer considerable ravage from the insects that meet with it: the swedes will be safer when made more general. In a "regular fly season" the few which are tried have been occasionally eaten off close to the ground, and yet are so hardy as to grow up again with vigour. Surely this hardihood

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of night soil mixed with 10 bushels of good loam, left in a heap for a year, so as to completely amalgamate, and drilled the next. This dressing is for one acre.

in growth, the superiority of their nutritive qualities,* their endurance of frost, and the greater weight per acre, must be invincible arguments in their favour, and such as will continue to extend their culture in this and other districts. Upon the Heath it is generally denied that more swedes would be an advantage, though merely a fifth part of the turnips are of that kind. Experience here must be deferred to, and its voice is given thus: "A few swedes are of service for late keeping, but the reason that more is not grown is because we can get a greater weight per acre of the white turnips." Swedes on the Wolds have seldom answered on a large scale, though repeatedly tried; and the practice of sowing a large proportion has been discontinued. If sown wide apart and allowed to get large, they canker and rot, whether left in the earth all winter or taken up; and if left near, they are small, hard, and of little value. In some localities it is complained that the land will not produce them of a sufficient size; and under a certain diameter any turnip will have little within it except rind. In other places they are considered as too exhausting for that light land; hence they are likely to continue rare in the district, the Scotch yellow (or green top) turnip, which bears the frost pretty well, being universally sown in small plots for last eating.

7. *The Grounds of the present practice of consuming the Straw with Oilcake given to Beasts on light Arable Farms.*

All the straw which is not required for bedding is consumed by the stock, because it forms a more valuable manure when converted into dung than when merely rotted into litter; and it is eaten by cattle, because they are the most suitable animals for the purpose. The more beasts there are kept the larger will be the quantity of dung; and the better the food with which they are supplied, the richer will be the quality of that manure. Of the various feeding stuffs purchased for cattle the linseed oilcake has become most general, and the extra food will therefore consist either of *oilcake* or *turnips* drawn from the land. The phrase "drawn" exactly expresses the reason why turnips are not commonly used in the straw-yards upon farms which grow them in perfection, and will not "trample into a state of clay" whilst they are being removed from the field: the light land has not the natural fertility which admits of such an abstraction of its produce, and could not bring a crop of corn if the roots (which had formed themselves chiefly from the air, on purpose as it were

* The nutritive value of swedes as compared with white turnips has been estimated as 5 to 3,—100 lbs. of good hay being equal to 308 lbs. of swedes, or 504 lbs. of white turnips.

to fertilize the soil) were to be taken away.* Instead of this it is found necessary to feed them off with sheep, thus changing them into dung on the spot; and it is common to treat the land still further by supplying these sheep with a portion of oilcake. The consolidation arising from their tread is also absolutely necessary in order to obtain a successful grain crop. The use of turnips in the yards being thus precluded, the farmer may either strengthen the manure with artificial food, or, leaving that weak and all but worthless, buy bone-dust and other portable fertilizers for his green crop. Universal experience has decided that light and frequent dressings of good cake dung are far more valuable, even on light soils, than any other kind of manure, and therefore the former plan would be the wiser of the two. The general practice, however, is to do both; and the advantages of this system, apart from the nature of the soil which renders it necessary, may be thus stated—the roots, instead of being consumed in the yards, are eaten on the land, thereby saving the carriage to and from the homestead, and occasioning a profit upon the growth and feeding of a flock of sheep in addition to that upon the growth and feeding of the beasts. If the turnips alone were to be given with the straw the only extraneous aid imparted to the soil would be the artificial manure employed in their production; but by the Lincolnshire method the roots are likewise consumed on the farm—only in a different place—the artificial stimulants are also applied, and in addition to, and independently of these, the oilcake is bought for improving the excrements of the cattle. The grounds upon which the practice is based are, therefore, simply the natural infertility of the land and the expectation of bountiful crops from the ample investment of capital in manures.

Where cattle are not bred, it is customary to buy in yearlings or two-year-olds in November, and feed them loose in courts or yards, 15 or 20 together, giving them from 2 to 4 lbs. of cake each per day. If older stock are purchased they have 4 to 8 lbs. of cake each daily, and are sold out in spring to be finished by graziers. The younger beasts are expected to pay as much by their growing as the others by their increase of flesh, but it rarely happens that either kind realizes more money than has already been expended in their food. It is a very common thing for a farmer to winter another person's beasts upon straw, without any money remuneration, the owner furnishing them with oilcake. On the light barley lands the cattle eat the barley straw and clover hay with oilcake, and are littered with the wheat straw. "Good manure,"

* In some localities on the Wolds the farmers could not pull their turnips if they wished. Labour is expensive, and there are no children to do the turnip work.

says a Wold farmer, "being essential to the successful management of chalk farms, and particularly needful for turnips—the mother of all crops."

In the northern portions of the county the cattle are chiefly obtained from Yorkshire, great numbers being annually brought over the Humber: Irish and Scotch beasts are also scattered throughout many districts. Breeding, however, is carried on in almost every locality; and the breeders in the north-eastern division of the county have certainly "achieved greatness" by their care and judgment in the selection of animals, and the rearing of young stock. Two subjects here present themselves, opening out into a wide field for remark; but as the Society has not made them topics for especial consideration, a word or two will suffice. With regard to the feeding of calves, and their after-management, different methods are pursued just as opinion dictates or experience teaches; some farmers rearing them by hand by means of milk, porridge, corn, cake, and hay, whilst others (probably the most superior breeders) allow the calves to suck their mothers during the day, and shut them in warm boxes at night.

The only sort bred in this county are short-horns, and the usual appellation of "Lincolnshire Short-horns" is truly applicable to the majority of animals, inasmuch as they partake largely of the old Lincoln breed, possessing the quality of the Durham short-horns, and retaining the size and majestic proportions, without the clumsiness, of the "old Lincolnshire ox." It is owing to this combination that the proportion of lean flesh, compared with fat, is greater in this breed than probably in any other, whilst the weight to which individual oxen have attained has perhaps never been exceeded. In fact, Lincolnshire is justly renowned for having triumphantly accomplished the grand difficulty in breeding, both with its cattle and sheep; it has united size with constitution and quality in such a degree as to retain the merits of each.

In the great north-eastern breeding district a portion of the cattle are remotely descended from the old Lincoln breed, but crossed for many years with good short-horn bulls, and the produce comprises many excellent beasts which, without being too pampered and tender, are capable of being converted into beef in a more reasonable time than those which have been bred from the deep-milkers and others not possessing very fattening propensities. They may be generally described as "Improved short-horns," but a considerable portion are perfectly pure in blood, and of high celebrity as first-class animals. Indeed more beautiful specimens can scarcely be found than among the pure short-horned herds of North Lincolnshire. The fine animals of

Messrs. Smith, Topham, Kirkham, Booth, King, Watson, &c., are well known to the graziers of Lincoln, Leicester, and other counties.

8. *The comparative merits of Rape and Turnips on Peaty Land, and the best mode of Growing and Feeding off Rape.*

Rape (*Brassica Napus*, L.) is a biennial plant of the turnip kind, but with a woody spindle-shaped root unfit to be eaten except when young, and is cultivated both for its seed for oil and as food for live stock. In the fens it is denominated coleseed, probably a corruption of "colza," although the French and Flemish colza differs from rape in its greater affinity to the cabbage, its rougher leaves, and greater hardiness. The leaves and brittle stems of rape are probably unsurpassed by any other vegetable as a green food for sheep, though certainly yielding on most soils a less bulk of produce than the turnip. Few crops are less liable to failure in consequence of the variations of weather, or the attacks of insects, and it is therefore no wonder that it should be extensively grown where the land is suitable. It requires a deep and rich soil, being partial to an alluvial clay, but thrives with greatest luxuriance upon peaty land. These considerations would alone be sufficient to explain the universality of rape throughout the fens, but a remark on the unfitness for peat soils of the crop which it displaces will at once demonstrate the wisdom of the choice. Turnips are rarely of good quality on peaty land; they are produced either very large or "fuzzy," or very close, "rindy," hard, and stunted, owing to the plants running to fangs instead of bulbs. On such land, therefore, rape excels the turnip both in quantity and quality; experience proving that here the one finds every condition favourable to its growth, while the other meets with influences which check or deteriorate it.

The cultivation of the land for coleseed resembles that for roots. On the light black land, which will not bear ridging, the seed is drilled on the flat in rows 12 to 16 inches apart; but, generally speaking, ridge culture is by far the better system. The fattening and nutritious properties of the plant are in proportion to the exuberance of its growth, hence are required a good heart in the soil and plenty of room above ground; and the best mode of culture will be to deposit 10 to 14 two-horse cart loads of good yard-manure in ridges 25 inches distant from each other. About 2 quarts per acre of seed, with 10 bushels of bone-dust, must be drilled in the months of June or July, though sowing is done in the fens at any time between March and August (both inclusive), so as to provide a succession of green forage crops for the sheep. A larger amount of seed is requisite when the land is poor and not so certain of a crop, but the plants ought at all

times to be thin along the rows. About a month after sowing the land should be horse-hoed, and harrowed with a triangular expanding ridge-harrow; on stiff soils this must be repeated several times, the effects of this constant tillage and pulverisation in forcing onward the crop being truly astonishing. If the plants are allowed to stand too near together, the stem grows weak and wiry, and the leaves become "foxy" red, or mildewed. When hoed out in a similar manner to turnips, but with a narrower hoe, there is a freer circulation of air and a larger proportion of nutriment for each plant; the stalks, which the flock prefer to the leaves, grow thick and juicy, and run up to the height of 3 or even 4 feet. On the best fen farms may be seen crops thus tall, and so closely set that the sheep are completely hidden beneath the branching leaves, and are compelled as it were to eat their way into the field. Coleseed is ready for stocking about 3 months after it is sown; the most common period being from the middle of September to the middle of October. A first-rate crop will carry 20 sheep per acre for 20 weeks, an inferior one perhaps only 5, much depending, of course, on the time allowed for feeding it off. The usual value of coleseed-keeping is from 30*s.* to 60*s.* per acre, and sometimes reaches to 4*l.* or more per acre. The animals fatten upon it with great rapidity, but such is the nature of rich growing coleseed that it frequently brings on inflammatory attacks ("red water," &c.), in which case recourse is had to a diuretic drench. A supply of salt is always desirable, as a preventive of unhealthiness. As the change from the grasses or clover to this superior nourishment is often attended with loss of sheep, it is highly advisable, in the early part of the season, to provide a "fall-back," or adjacent stubble-field into which the flock may retire at pleasure. A small stack of straw, or a quantity of straw placed between hurdles for the sheep to pull at, is useful, especially in wet weather. Cut oat-sheaves given in troughs are also an admirable addition to their food whenever signs of unhealthiness become apparent; and a small allowance of cake or corn ought not to be withheld. The field, if large, should be partitioned by "trays" (or hurdles), and the sheep be thus allowed a fresh piece at certain intervals; a considerable amount of waste from trampling, &c., being by this means prevented, and the sheep kept more healthy than if suffered to roam over the whole field—when they eat little else but leaf during the first part of the time, and have no layer but amongst the lofty vegetation continually wet with dew.

A light and cheap shed or shelter—the walls constructed of a double row of hurdles, with straw packed between, and the flat roof made with poles, hurdles, and a thick covering of straw—is of benefit to the stock in pinching weather; they will invariably

be found to lie within it at night, and the litter in and around it becomes excellent manure.

9. *The Condition of the Labourer and the Improvement required therein, by bringing his Dwelling nearer to his place of Labour.*

In treating this most difficult and most important subject, a few words are premised regarding the state of the industrious poor at the period of Young's Report in 1799, or rather to compare or contrast his details with the few which have been gathered in 1849, and thus learn whether progress or retrogression has been the order of movement since that time.

From the monthly averages for different counties, published in the 'Annals of Agriculture,' it appears that the prices of wheat in 1797-8-9, &c., varied amazingly at the same time, according to the inland or maritime situation of the county, the monthly average of one county being sometimes 50*s.* per quarter when that of another was 76*s.* 8*d.* per quarter: cheaper modes of transit have, however, prevented such a state of things happening at the present day. The average value of a quarter of wheat (Imperial measure) in Lincolnshire, during 1797, was about 44*s.*; in 1798 about 43*s.*, and in 1799 about 52*s.*; giving about 46*s.* during the whole period to which Young's notes refer. He fixes mutton at 6*d.* per lb. all over the county, pork from 5*s.* to 7*s.* per stone, potatoes 3*s.* per sack, coals 18*s.* to 30*s.* for a chaldron of 48 bushels. At the present time the price at Boston market is a fair criterion of the general price throughout the county, and through the year 1849 the average was somewhere about 44*s.* per quarter; and the general rates for other provisions may be stated at 5*d.* per lb. for mutton, pork 5*s.* per stone, potatoes 5*s.* per sack, and coals 22*s.* per chaldron of the same measure. As wheaten bread forms the principal necessary of life to the Lincolnshire labourer, it appears that the value of food is not materially altered from that in the year 1799; and the increase or diminution of his wages in comparison with that period will be a fair indication of the improvement or falling off in his means of living. Clothing is probably much cheaper, tools have been greatly improved; but to counterbalance this the potato failure has made pig-feeding expensive, and the garden plot less remunerative than of old.

The following is the common rate of wages in different districts in 1849 and previous years, but owing to the further fall in the prices of agricultural produce a reduction to 10*s.* and even 9*s.* has subsequently occurred in many places here mentioned at 12*s.* In the present unsettled state of the farmers it is difficult to say what wages will ultimately be. On the Wolds the general wage is 12*s.* per week, the men working from 6 o'clock to 6, with a rest

at dinner hour. Many receive 13*s*. 6*d*.; but in winter the rate is frequently lowered to 10*s*. or 10*s*. 6*d*. In harvest, of course, the wages rise; the cutting is done "by the grate," the wheat at 6*s*., 7*s*., and 8*s*. per acre, and barley 5*s*. The wages on the eastern Clay and Marsh district were 12*s*. to 15*s*. per week in summer, but 10*s*. in the winter of 1849-50. In the central district wages are now from 10*s*. to 12*s*., the labourers at taskwork earning 2*s*. 6*d*. per day. The general wage in the north-western district is 12*s*., but during this winter only 10*s*. 6*d*., varying from 9*s*. to 12*s*. The present rates in the Isle of Axholme are 10*s*. to 15*s*. per week. The wages on the Cliff during the same winter are 10*s*.; the winter before the minimum was 12*s*. per week; on the Heath at the present time, 10*s*.; in the south-western district, 10*s*. The general wages in the Fen and Marsh district are 12*s*. in summer and 10*s*. in winter, the hours being generally between half-past six and half-past five o'clock, but many farmers have at present dropped to 9*s*. The reaping and mowing in harvest varies from 8*s*. to 14*s*. per acre, all by the piece. The average of the foregoing minutes is about 11*s*. per week, excluding harvest, but the average of the county is probably more. The average of the same number of figures collected by Arthur Young is about 11*s*. 6*d*. without the harvest; and this comparison, therefore, shows pretty clearly that after the lapse of half a century the agricultural labourers of Lincolnshire are obtaining no better livelihood in exchange for their toil than before.

In most parts of the county it is customary to pay a shepherd and a waggoner, or "head-man," at a higher rate; a "middle-man," and very frequently 2, 3, or 4 (and on the Wolds often 7 or 8) young men-servants are boarded in the farmer's house, or in a cottage on the premises,—their yearly wages being from 4*l*. to 7*l*., and their fare bread, bacon, milk, and beer. Paying in kind is not a common practice: task-work is very generally done in small matters, but an extension of it is highly desirable both for master and man. Hollow-draining, ditching, corn-hoeing, turnip-hoeing, manure-turning, flail-thrashing (and sometimes also by horse), claying, chalking, hay-mowing, corn-cutting, &c., are commonly executed by the "grate," when the workmen (with women and children to assist in several of the operations) generally obtain a small "reach" in addition to their daily wages. Women and girls are employed in weeding and other operations, though very seldom in harvest work; gleaning for themselves is then their occupation, and in most parts of the county they are allowed to enter a field directly the crop is carried, the quantity of corn thus gathered in the season being from 4 to 8 bushels, by the best hands 10 to 12. Boys are required at almost all times for weeding and cleaning land, picking off stones, frighten-

ing birds, driving pigs, &c.,—their wages varying from 4*d.* to 6*d.*, 8*d.*, or 10*d.* a day; girls about the same; and women 10*d.* or 1*s.* per day. The height of wages in Lincolnshire, as compared with many other counties, and the general lowness of the poor-rates,* intimate a comparative abundance of employment; and the following testimony will confirm such an inference. Personal observation and inquiry by the writer during a tour through the county, and the statements contained in correspondence from upwards of twenty of the most intelligent farmers in all parts of it, justify the conclusion that the labourers *generally* are regularly employed and *comparatively* well paid. On the Wolds there is full occupation for them; in the central district "they are *well employed*," "all are employed;" on the Cliff and in the north-western district is "plenty of work;" in the Isle of Axholme "the labourers are fully employed,—women, and children above ten years of age, have nearly full employment at from 9*d.* to 2*s.* per day, viz., 2*s.* per day in harvest, 1*s.* 4*d.* per day when taking up potatoes, and 9*d.* per day for weeding, planting, and assorting potatoes;" on the Heath and the districts east and west of it, general employment is the rule. In some parts of the south-western district there is "a superabundance" of labourers, that is, there are more than the occupiers of the cold lands think they dare employ, and consequently many are often out of work for a long time together. By referring to the account of the management of this land and the farmsteads upon it, it will be seen that many improvements in tillage and in feeding a greater proportion of stock, &c., might be instituted that would absorb this surplus of industrial beings. In the clay district north-east of Louth a similar lack of employment appears to exist. From other parts of the same tract the information is, that "the condition of the labourers has been hitherto good, there being generally employment for them all;" but here it is affirmed there has lately been "a great change for the worse, and they cannot be employed at any rate of wages, excepting a few of the best hands at 9*s.* to 10*s.* per week." This is a truly deplorable state of things, and one which demands an instant remedy. It is attributed in the locality to the depression of prices; if this be true, and if the occupiers are unable to substitute an outlay of capital in improvements for a political relief, why should they not seek for such an adjustment of their necessary expenditure to the value of their produce as may enable them to waste no longer the sinews and skill which earn them profit? In most of the Fen and Marsh towns "idle hands" may

* The number of paupers in this county, as compared with the total population, is only about six per cent.; whilst in Norfolk and some other counties they amount to 10 per cent.; and the Union Workhouses are occupied by only one-third the number of inmates they could accommodate

often be seen in the market-place during the winter; but the workmen are kept well employed throughout most part of the year.

Judging from the statements made by Young, it seems that a similar industry marked this county in his time: he speaks of Lincolnshire as "a county where wages are as high—probably higher than in any other county in the kingdom;" says, "the poor-rates are very low," and shows that able-bodied paupers were few. Hence it may be concluded that increase of employment has kept pace with the increase of labouring population. Now as wages are the same at the present time as in 1798-9, it will follow that the whole expense of manual labour in 1849 is just as much greater than the same expense in 1799 as the population of one period exceeds that of the other; or in other words, the whole cost of manual labour has increased during fifty years in the same ratio as the population. That ratio is about 87 per cent.; for as *enclosures* and *drainage* have been the chief cause of the increase, the number of labourers (notwithstanding emigration) has in all probability swelled equally with that of citizens in the towns. By referring to the close of this Report it will be seen that the rental of the county has also increased about 87 per cent. in the same period: so that landlords and labourers share about equally in the fruits of the agricultural improvements. But while the latter who have worked are, from their increase, no better off *individually*, the great landed proprietors (who merely own), being a comparatively unincreasing class, have been individually enriched. If this apportionment is in accordance with right and justice, at any rate the toiling but unprogressing poor must expect to receive bounties from the landowners in some shape or other.

Coal and clothing clubs are frequently found in the villages, and there are many savings-banks. Public charities abound; endowed almshouses are frequent, and almost every parish possesses benefactions of money or land for periodical distribution. Numerous associations exist, the sole object of which is the rewarding of labourers, and in some districts are very near together,—as, for instance, at Boston, Alford, Horncastle, Donnington-on-Bain, &c.; and premiums for workmen form also a conspicuous feature in many societies that hold shows of stock.* Benefit societies are plentiful, and well supported by the labouring population, consisting of Friendly Societies, Odd Fellows, Foresters, and Shepherds' Lodges, &c., which are undoubtedly of great advantage to the artizan and labourer by collecting small sums from time to time, and disbursing them again as a weekly allowance in the season of sickness and calamity. Of the bless-

* Perhaps it is worth noting that in Lincolnshire are upwards of 17 Agricultural Associations, Farmers' Clubs, and Societies for rewarding Labourers, and 178 members of the Royal Agricultural Society.

ings accompanying the Allotment system enough has been published to show that a wide adoption of that system is needed throughout the kingdom, providing that it be done upon suitable and equitable principles. In Lincolnshire it is frequently but not generally found, the various examples being of a pleasing and satisfactory character. A plot of land adjoining his cottage is of more value to the labouring man; and it is here that improvement is greatly required in most parts of the kingdom. Though a great portion of Lincolnshire belongs to large landed proprietors, there are in it more small freeholders and copyholders than are to be found in most other counties in England, hence the prevalence of the cottage system. Arthur Young says—"It is impossible to speak too highly in praise of the cottage system of Lincolnshire, where land, gardens, cows, and pigs are so general in the hands of the poor. Upon views only of humanity and benevolence it is gratifying to every honest heart to see that class of the people comfortable upon which all others depend. Wherever this system is found poor's-rates are low; and another object, yet more important, is the attachment which men must inevitably feel to their country, when they partake thus in the property of it."

In the winter of 1800-1, Mr. Gourlay visited eight villages in Rutland and thirty-two in Lincolnshire, and published a Report of the cottages in each parish, in the 'Annals of Agriculture.' The average population of each was 226·3, the average number of cottagers with cows 15·4, the quantity of land occupied by each cottager 6·4 acres, the live stock kept were both cows, pigs, sheep, and horses, the average being equal to 2 cows and 2 pigs to each cottager. In those parishes where cottagers had cows the poor's-rates averaged 1*s.* 5½*d.*; in those where few or no cottagers had cows, 5*s.* 11*d.* And a table is given, showing that in proportion as the number of cottagers *decreases*, the rate and average expense to each individual *increases*. At the present time gardens are universally attached to the cottages, but the "six acres" of ground has certainly been very much curtailed, and cows are comparatively rare. Most of the labourers have 1 or 2 pigs each to fatten. As population has increased new houses have been built, but without a proportion of land being set apart for them sufficient for grazing cows or sheep. In the marsh and fen districts, and other clay lands, a large proportion of the cottages in Young's time were constructed of "stud and mud," *i.e.*, with walls of wood and clay, and many yet remain; the principal portion of the newer cottages, however, are of brick, tile, and slate. Reed thatch was the old-fashioned material for roofing, but is very little used in modern erections. Many convenient and comfortable habitations are to be seen in all parts of the county, but a greater part of the cottages are small, low, and incommodious;

the interior is generally damp, dark, and badly-ventilated, and parents, sons, and daughters are frequently crowded into a single sleeping room. It is gratifying to find that both the prizes for Essays on the "Construction of Labourers' Cottages"* have been won by individuals in Lincolnshire; and perhaps this may betoken the awakening of a general spirit of inquiry into this department of rural economy, and that houses in future will be built with all the necessary appurtenances of copper, oven, &c.

In the south-eastern lowland the cottages are tolerably good, small garden-plots general, and 1 or 2 pigs universally kept. The distance from the place of labour is not great, owing to the comparatively recent settlement of villagers in almost all parts of the newly-drained fens. The condition of the labourers in the south-western district is not good; " they rarely keep cows, but most of them have a pig, and there are generally plenty of cottages, usually with small gardens attached." On the Heath, most of the poor have pigs, and " have on an average 2 miles to go to their work." In the north-western district " the cottages are comfortable, with from 1 to 3 roods of potato ground;" and generally with the keeping of 1 cow, pigs, &c., from 7*l.* to 8*l.* per annum. " A large portion of the labourers keep a cow, so that those who have a cow can keep 2 pigs; and those who have not a cow generally keep one. Few of them have occasion to go more than a mile to their work." In the Isle of Axholme a similar state of things is to be found; the gardens grow potatoes, with which pigs are fed, and many of the labourers are able to keep a cow, or "joist" one upon a neighbouring farmer's land. In the central district the condition of the poor is good, and in the several parishes around Wragby they are " all supplied with gardens and good cottage-houses." Nearer Spilsby "the men find plenty of work: their houses are bad, many being ornamental outside but inconvenient within." In the flat tract, between the chalk hills and the coast, " the condition of the labourers is superior to the general average, having many cow cottages." In the southern parts "the cottages are in most cases too small for a family." On the Wolds they generally have garden sufficient to feed 1 or 2 pigs, and, in some localities, land for a cow's grass and hay, and the cottages are pretty good. It may be here remarked that very few cottages in this county are sub-let by farmers, the landlords having taken them into their own hands, thus giving to the labourers an independence that they would not otherwise possess. The chief defect with regard to the houses of the poor is in their *number*, for in many localities on the Wolds, Cliff, and other districts, the no-cottage system seems to prevail.

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* Journal, vol. x.

Where villages cluster most closely together it is common for the men to walk a mile to their work; but in many districts, particularly where the parishes are thrown into one or two farms each, one large village supplies all the surrounding farms with labourers, who have to travel 3 or 4 miles every morning and night to and from their labour. This is the case at Binbrook and many other places on the Wolds. The population is very unevenly distributed; and the cause invariably assigned is the unwillingness of parishes and proprietors to rebuild old houses or erect new ones, in consequence of the "Law of Settlement." They wish to keep down the population in their respective parishes, with a view of having less poor-rate to pay. At Winterton, for instance, are numerous freeholds and small occupations of land, arising in a great measure from the reluctance of neighbouring landowners to rebuild or erect cottages. Labourers being thus driven out of other parishes find a home here, and many are able to hire an acre or more of land (for perhaps 5*l.* per acre), which their families, being out of the reach of paid employment, cultivate; whilst themselves are obliged to walk a great distance before and after their day's work. In the neighbourhood of Kirton-in-Lindsey there is again the same lack of cottages, the owners neither building nor repairing them, because they would be obliged to support the families which might settle there. Consequently this town, having many small freehold estates, is crowded with the poor from other parishes, who hire dwellings here and go 2 or 3 miles to work. The above are spare examples, but abound in many parts of Lincolnshire. Now the Settlement Laws have assuredly much to do with this question: at present the paupers in each Union are paid for out of a general fund, but the parishes in which they have resided are assessed according to the amount of relief respectively received by those parishes; and if the settlement were made to refer simply to different unions, and an equalization of rate should take place throughout all the parishes joined in each, the proprietors would probably see the folly of attempting to exterminate the poor in order to lessen poor-rates, and would not object to the workman living near the spot of his labour.* But without an alteration of this kind, under the present circumstances of the case, this practice of refusing to build, when rent would remunerate as in other outlays, must be denounced as inhuman, unjust, and impolitic. It is inhuman and cruel to compel the poor to live in a place far removed from their work, thus imposing additional hours of labour and fatigue upon them, and to force

* Petitions to Parliament from Louth, &c., complain of the hardship and injustice arising from the laws relating to the parochial settlement of the poor, and pray for an equalization of the poor-rates.

them to pay heavy rents for mean dwellings in consequence of an undue competition in the freehold villages. It is unjust to accumulate hardships upon the toiling classes, to rob them of that time which might be devoted to the improvement of their mental and moral faculties, and deprive them of opportunities for adding to their domestic comforts; and unjust also to the parishes in which the labourers herd together, the rates of which the neighbouring but unneighbourly townships are relieved falling with greater burden upon the populous ones; the system being likewise not only a shirking of honest liabilities by those who ought to pay them, and an imposition of those debts upon others, but (contrary to design) an actual increasing of the whole poor's-rate—for how can the privations of insufficient house-room and extra labour tend to anything but a greater degree of poverty and suffering and a wider demand for relief? And this practice is not only disgraceful, but impolitic; for how are the labouring population to respect and honour the higher classes under such treatment as this; when, from the doubled value of the land, the least that could be expected is that the proprietors should provide suitable houses at low rents for the class by whose industry they have profited? It is unwise and imprudent, because the farmers also suffer by it; the men will not go to the more distant occupations, until every source fails them nearer home and distress obliges them to this extra toil, so that hands are often scarce in remote situations. Again, in some critical seasons, when workmen must be had, they will not labour for the usual number of hours in consequence of their long morning and evening journeys, and the farmer has to employ an extra man to make up for the loss of time. This is therefore a question between landlords and tenants; and in the present state of the times the latter feel entitled to claim every reasonable advantage. Finally, it may be safely inferred that whatever tends to the improvement of the labourer's condition is a benefit to the farmer and landowner, and a profit to the whole community, and that anything which injures and degrades his social well-being is also a loss to the perpetrator and a wrong to society.

A word now as to the labourer's diet. Probably, very few families make their own bread, except from the flour of their "gleant corn," and though the profits of the bakers in a rural district are usually considered to be none of the smallest, it is likely that the expediency of the custom may be accounted for on the principle of the division of labour. But the poor generally purchase the *finest* loaves—a practice seemingly of unnecessary expense, but which may be both reprobated and defended. The same weight of bread made of "thirds" flour would cost less by 1*s*. or 1*s*. 6*d*. per week, and be much more wholesome and nutri-

tious. On the other hand experiment has shown that the coarser food being so much better and more agreeable, the people eat more of it; and the general practice of those who are interested in spending their own money to the best advantage appears to ratify this conclusion. Economy is doubtless the motive for buying the white bread; but certainly they who work hard for a living are entitled to choose their own food, and ought to have the best of the plainest fare. In conclusion, much might be said repecting improvidence, intemperance, unthriftiness; but this article has already occupied a large space, and did not the fear of becoming tedious prevent, the writer could not close without a reference to the extended means of education enjoyed by the humbler classes in this county, and to the respectable appearance presented by Lincolnshire labourers on the Sunday, without an observation on the moral benefits accruing from cottage flower-gardens, &c., and without an eulogy on behalf of the poor, on that most useful and inestimable, yet much maligned animal—the hog.

An apology for the length of this Report in proportion to others in the Journal, is contained in the list of "heads" proposed by the Society. The Soils of Lincolnshire, especially of its marshes and fens, are too peculiar and important to be passed over with a word; no county possesses so remarkable a feature as the great drainages which have been glanced at with a brevity disproportioned to their interest; the Agricultural Management is that of a first-class district, and therefore meriting a conspicuous place before the public attention; the claims of the Labourer to have his circumstances fully pourtrayed, no person will dispute; and the Live Stock, Green-crops, and Farm-yards have certainly not engrossed too large a share of space. Private opinions and personal allusions regarding the different subjects have been but little indulged in; conjectures with reference to the total rents, productions, &c., of the county have been mainly avoided; and this Report is therefore merely a record of facts gathered from personal observation and inquiry, and reduced to shape.

The extent to which agricultural science has been carried into practice in Lincolnshire has now been investigated; and the results of the whole inquiry may be comprehended in a short summary. *Drainage*—the first of all improvements—has been well done over a great part of every district requiring it; a remark untrue of many English counties. *Subsoil* and *trench ploughing*, however, are rarely found; and this forms a considerable defect in the heavy land management. The *systems of culture* are well adapted to the climate, soils, and situation, an alternate course of cropping being the most predominant, marked by a tendency to keep half the land under wheat or other white corn, and by a diminishing of the quantity of bare fallows. In the *breeding of*

live stock, and *feeding* with *oil-cake,* bruised grain, &c., to enrich the manure, this county is probably inferior to none; and its imports of *guano,* and more largely of *crushed bones,* are a high testimony to its enterprise and liberal expenditure. In the providing of *house accommodation* for stock, and *receptacles for manure,* a great deal remains to be done; in many districts the general want of warmth and shelter, and the wastefulness exhibited in these departments, cannot meet with commendation. The annoyances of *game,* encroaching *fences*, and *hedge-row timber* are extensively felt, but are perhaps much less burdensome than in some other counties. The Lincolnshire *implements* are of an improved kind; the wrought-iron ploughshare has not yet given way to that of cast-iron, but most of the larger cultivators and improvers use the latter. The Yorkshire wooden swing-ploughs (substituted in the Fens for the antique one-handled plough) continue general; the Rutland wheel-ploughs are frequent in some districts; and iron ploughs are frequently seen upon the hills. One of the larger deficiencies of Lincolnshire agriculture is the lack of fixed *steam machinery* for thrashing corn and preparing it for market, &c. Horse-power has been commonly employed for knocking out the grain, and the winnowing is universally performed by riddles and hand dressing-machines. Latterly, portable steam-engines for thrashing have very much increased in number; many occupiers have engines of their own, but the general method is for a machine-man to purchase one and let it out to neighbouring farmers.* They are common in nearly every part of the county, and have effected a great saving of horse labour. Fixed steam-engines, however, are very rare, although increasing in number; they are found upon some of the larger occupations, where they economise labour and clean the corn into a perfectly equable sample.†

The "living machines," or *farm-horses,* are strong and useful, though they have not attained a celebrity like the Suffolk or Clydesdale breeds. Some years ago the Fens were noted for their black cart-horses, which fetched a higher price in the market than perhaps any others in the kingdom; but since the inclosure comparatively few have been bred.

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* They are often furnished with apparatus for shaking the straw as it falls from the drum beaters. The charges are—Wheat 2*s.*, barley 1*s.* 6*d.*, oats 10*d.* per quarter; where the custom is for the engine-man to find everything but one man, he furnishes coals, &c., and "chaffs" or "roughs" the corn once over with a roughing-machine. In some localities, where the straw is long, the usual rate for wheat is 9*d.* or 10*d.* per quarter, the farmer providing coals, hands, and indeed all that is needful, except one man.

† At Trusthorpe, in the north-eastern marshes, is a fixed steam-engine, which thrashes and dresses perfectly, with only two men being employed after the feeder, viz., one removing the sacks when filled, and another attending to the winnowing machines. The "blower" is much superior to riddles for "finishing;" the wind is regular, at a constant pitch, so that the excellency of the sample is determined by setting the machine to a certain gauge.

The *condition of the labourer* is undoubtedly of a superior order as compared with what it is in most agricultural counties, but to say that it is "good" is a matter which admits of hesitation; how the workmen exist in those counties where 7*s.* or 8*s.* is a common weekly wage (*without* a constant supply of ale, cider, malt, &c.) must for ever remain a mystery to many, when 9*s.*, 10*s.*, or 12*s.* is here deemed a miserable pittance on which to feed, lodge, clothe, and warm 6 or 7 individuals for seven days.

To show the amount of improvement which Lincolnshire agriculture has experienced in fifty years, we may just give a comparative estimate of the former and present rental. By comparing the average of the minutes gathered by Young as to the "rent" in 1799, with the average of similar items contained throughout this Report (of course making due allowance for the difference between an average of *minutes* and the average of the *county*, owing to the variable areas to which the stated sums refer), it appears that there has been an increase of about 87 per cent.; and this calculation is not very far from the truth. Young divided the county into wrong proportions, and computed the whole area of surface at much more than the truth; but his divisions are here followed pretty closely for the sake of comparison:—

	1799.				1849.			
	Acres.		*s.*	*d.*	Acres.		*s.*	*d.*
The Lowlands .	776,960	at	23	0	630,000	at	40	0
The Wolds . .	234,880	,,	9	0	230,000	,,	27	0
The Heath . .	118,400	,,	8	4	120,000	,,	30	0
Miscellaneous .	718,080	,,	14	0	620,000	,,	25	0
Total . . .	1,848,320	,,	16	9¼	1,600,000	,,	31	0

By comparing the details of acreage produce given by Young, with those in this Report, a considerable augmentation since that time will be observed; and still further, when the vast improvements in the breeds of sheep and cattle, and numerous other departments of husbandry, are taken into account, it will be seen how greatly the farm productions of 1849 exceed in quantity and value those of 50 years ago. And when the enlarged amount paid for labour is also considered,—the cumulative Returns which have been produced since the time of the last Lincolnshire Survey are more clearly apparent.

As all reports of this kind are intended for some more useful and practical purpose than gratifying curiosity, it is now for the reader, perusing the details which illustrate the foregoing points, to say how far the landlord who lets, the farmer who occupies, and the peasant who labours, are respectively concerned in promoting the various improvements implied or suggested. *Capital* and *skill* have here applied physical and chemical laws to the formation of new soils, by the deposition of warp and the disin-

tegration of rock, and, by another species of art, have refined the unwieldy ox and coarse-boned sheep; this Report declares what improved operations of husbandry they are at present performing; and who can tell but that with an adjustment of the claims of the industrious classes obstacles of price shall yield like others to their growing strength, and "Lincolnshire farming," with British Agriculture, once more enjoy a sound prosperity, cheered by a brightening prospect of the future?

XVIII.—*Report of Experiments on the Comparative Fattening Qualities of different Breeds of Sheep.* By J. B. Lawes, Rothamsted, Herts.

Hampshire and Sussex Downs.

It is obvious that wherever that system of farming prevails which is characterised by an extensive growth of root crops, and the consumption of a large quantity of what is termed "artificial food" by stock, a very different character of sheep will be in request from that which is adapted to roam over large tracts of scanty herbage. In the latter case that description of animal is valued most which is best able to exist with a scarcity of food, the result of which is to lessen the tendency to *early maturity*; and although this method of feeding will probably always be found the most advantageous one in some localities, yet there cannot be a doubt that in the course of agricultural progress a tendency to early maturity, or the aptitude to increase rapidly upon a liberal supply of food, is a quality which is increasingly sought after by farmers.

Without, then, in the least degree depreciating the importance of other qualities than that of *rapid fattening*, it is assumed that a *knowledge* as to which breed of sheep will give the greatest increase upon a given quantity of food, and within a given time, during the period of fattening, is at least a great desideratum; and it was therefore determined to undertake some careful experiments in reference to this point, with the breeds of most importance in this country. Accordingly a comparative trial has now been made between the Hampshire and Sussex Downs, the results of which are given in the present paper; a similar experiment is now in progress between the Cotswold and New Oxford breeds; and it is proposed in the following year to undertake the Lincolnshire and Leicestershire breeds.

The county of Sussex has long been famed for its breed of sheep known by the name of *Sussex Down*, which, by the united efforts of individuals whose names are familiar to all who are conversant with the progress of agriculture in Great Britain, have

attained a high degree of perfection. Indeed, it may almost be said that they have the character of possessing such a combination of useful qualities as is scarcely to be found in any other breed of sheep, uniting, as they do, quality of mutton with quality of wool, a good constitution, and the capability of travelling long distances for their food, and maintaining their condition where many other breeds would starve.

A little further west another description of sheep prevails, and is distinguished as the *Hampshire Down.* Although this breed partakes of many of the characters of the Sussex Down—and both may probably have sprung from one common origin—yet, it nevertheless possesses some clearly distinctive qualities. Thus the delicate head, small legs, and symmetrical proportions of the well-bred Sussex sheep are not to be found in the Hampshire; but in the place of these we find a larger frame and heavier weight both of carcass and of wool, though with slightly diminished quality in each; and the animal, which owing to its increased size sells for a higher *price* when fat, is said to possess more of the tendency to early maturity than the Sussex sheep.

A difference of ten or twelve shillings per head on the fat animal is indeed at first sight evidence of a very tangible kind in favour of the Hampshire sheep; but the question of the cost of producing this increased value is in fact a somewhat complicated one. An accurate solution of it is, however, absolutely essential before we can fairly decide upon the comparative profitableness of different breeds, varying thus in weight and price. To this end it is obviously necessary to determine the quantity of food consumed in each case to produce a given amount of increase, and the money value of such increase; and it is as a contribution to this important subject that the account of the experiments already made with the Sussex and Hampshire Downs is now presented to the reader; that he may be able to form his own conclusions respecting them, the results will be given in full detail.

For the purposes of the experiment fifty Hampshire wether lambs were carefully selected at Overton fair in July, 1850, by a friend to whom the object in view had been communicated, and the animals arrived at Rothamsted early in August.

The selection of fifty Sussex lambs was at first kindly undertaken by Mr. Thomas Ellman, who intended to procure them at Lewes fair in September; but having been erroneously informed that some had been already purchased, he did not do so, and eventually fifty Sussex wether lambs were selected from the flock of Mr. H. Sadler, of Mid Lavant. These were forwarded to London by railway, and they reached the farm from thence on the 23rd of October.

Up to this time the Hampshires had been fed upon pasture merely. Both lots were now provided with a portion of white tur-

nips thrown down to them in the pasture; and they were thus kept until the exact experiment was commenced.

As the soil on the farm at Rothamsted is heavy and not well adapted to carry stock in winter, it was decided that the experiment should be made under cover. Accordingly, on November 7th, the whole of the animals having been previously weighed and marked on that day, 40 of the more uniform of each breed were placed side by side upon rafters in a long shed. The ten remaining of each were sent into the field with the rest of the fattening flock.

With regard to the selection of the sheep as above described, it may be remarked that many farmers and sheep-breeders examined them during the progress of the experiment, and expressed themselves fully satisfied with the character and quality of both the lots, but more especially with the Sussex sheep, which were particularly pure and uniform.

The *dry foods* selected were *oil-cake* and *clover chaff;* and these were given to the two lots respectively in fixed quantity, exactly apportioned to the average weight of the animals. Thus the 40 Hampshires, whose average weight was 113¾ lbs., had 40 lbs. of oil-cake and 40 lbs. of clover chaff per day; or 1 lb. of each of the two foods per head per day. But the 40 Sussex sheep, whose average weight was only 88 lbs., had 32 lbs. of oil-cake and 32 lbs. of clover per day; or rather more than ¾ lb. of each food per head per day.

Swedes were also given to both lots, as many as the animals chose to eat, but from stocks which had been previously weighed.

During the progress of the experiment the animals were weighed every 4 weeks, and always, as nearly as possible, at the same period of the day, the hour chosen being from 10 to 12 A.M., before the second feed in the day, as it was considered that at that time the weights would probably be less affected by irregularity in the contents of the stomachs and intestines of the animals than at any other.

In Tables I. and II., which follow, are given :—

The weight of each sheep when put up, Nov. 7th, 1850.

The increase of each animal between each period of weighing, and the weight of wool, shorn March 27th, 1851.

The total increase of each animal (inclusive of wool).

Their final weights, both inclusive and exclusive of wool.

Also, in the 12th column of each Table, the average weekly gain of each animal; and at the foot of the Tables the total gain of the 40 sheep between each period of weighing, and the average weekly gain, &c., per head of the 40 animals during the same period.

TABLE I.—Increase, &c., of Hampshire Sheep. Quantities in Pounds and Ounces.

Numbers.	Weights when put up, Nov. 7.	Increase in 4 Weeks, up to Dec. 5.	Increase in 4 Weeks, up to Jan. 2.	Increase in 4 Weeks, up to Jan. 30.	Increase in 4 Weeks, up to Feb. 27.	Wool shorn, March 27.	Increase (including wool), in 4 Weeks, up to Mar. 27.	Increase in 4 Weeks, up to April 24.	Increase in 2 Weeks, up to May 8.	Total Increase in 26 Weeks (inclusive of wool), up to May 8.	Average gain per Week of each Animal.	Final Weight, May 8, and wool.	Final Weight, May 8, (without wool).
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs. oz.	lbs.	lbs.
1	114	13	8	9	10	6	13	5	6	64	2 7¼	178	172
2	119	12	13	10	9	4½	14½	10	7	55¼	2 2	174½	170
3	124	9	19	17	17	5¼	22½	0	12	96¼	3 11¼	220¼	215
4	109	8	7	11	10	6½	9½	13	8	66½	2 9	175½	169
5	118	12	8	4	11	7	8	11	9	63	2 6¾	181	164
6	124	17	7	11	10	6	9	10	9	73	2 13	197	191
7	125	10	12	4	16	6¼	9¼	9	9	69¼	2 10¼	194¼	188
8	119	12	10	20	16	5½	20½	9	12	99½	3 13¼	218½	213
9	120	14	9	11	12	5½	10½	7	7	70½	2 11¼	190½	185
10	102	10	7	9	8	5½	8¼	15	6	63½	2 7	165½	160
11	112	12	7	9	12	7	8	7	11	66	2 9	178	171
12	116	5	13	9	6	7	11	13	4	61	2 5½	177	170
13	112	8	7	14	11	6½	10¼	13	9	72¼	2 12¼	184½	178
14	108	11	9	11	8	5½	8¼	14	8	69½	2 10¼	177½	172
15	105	6	13	7	6	6	10	5	7	54	2 1¼	159	153
16	112	9	13	7	13	5¾	16¾	8	12	78¾	3 0½	190¾	185
17	104	12	7	10	9	6¾	8¾	6	8	60¾	2 5¼	164¾	158
18	116	12	13	9	17	7½	12½	13	6	82½	3 2¾	198½	191
19	120	5	8	8	18	5½	17½	11	0	67½	2 9¾	187½	182
20	127	8	16	11	19	8	11	4	9	78	3 0	205	197
21	131	10	11	11	8	6½	15½	12	1	68½	2 10¼	199½	193
22	117	16	8	10	11	7½	12½	8	5	70½	2 11½	187½	180
23	113	12	9	6	13	5¾	12¾	12	8	72¾	2 12¾	185¾	180
24	117	17	12	4	8	5¼	14¼	15	5	75¼	2 14¼	192¼	187
25	111	3	9	7	8	6	10	10	9	56	2 2¼	167	161
26	115	17	9	13	9	6½	12½	10	3	73½	3 13¼	188½	182
27	127	19	10	9	12	6¼	4¼	12	9	75¼	2 14½	202¼	196
28	106	15	9	9	11	6½	11½	14	7	76½	2 15	182½	176
29	117	11	10	9	9	6½	6½	12	8	65½	2 8	182½	176
30	105	13	4	8	4	7½	9½	8	9	55¼	2 2¼	160¼	153
31	94	6	6	7	8	6¼	10¼	12	9	58¼	2 3¾	152¼	146
32	112	15	14	16	18	6½	13½	12	7	95½	3 11	207½	201
33	108	8	10	8	13	7	9	14	7	69	2 10½	177	170
34	113	8	9	12	13	5½	10½	13	3	68½	2 10¼	181½	176
35	114	7	9	7	9	8¼	11¼	9	8	60¼	2 5	174¼	166
36	96	3	6	8	8	5¾	10¾	10	9	54¾	2 1¾	150¾	145
37	108	6	7	7	11	5½	9½	8	7	55½	2 2¼	163½	158
38	116	17	8	14	14	8	16	16	3	88	3 6¼	204	196
39	100	11	11	6	11	6	11	9	9	68	2 10	168	162
40	112	10	8	10	9	4½	12½	9	8	66½	2 9	178½	174
Totals . . .	4538	429	385	382	445	250¾	462¾	388	293	2784¾		7322¾	7072
Means & Average Weekly Gain per head during each period.	Mn. per head 113·4 lb.	lb. oz. 2 11	lb. oz. 2 6½	lb. oz. 2 6⅜	lb. oz. 2 12½	Mn. per head 6 lb. 4 oz.	lb. oz. 2 14¾	lb. oz. 2 6⅘	lb. oz. 3 10¼	Mn. per head 69 lb. 9⅗ oz.	lb. oz. 2 10¾	Mn. per head 183 lb. 1 oz.	Mn. per head 176·8 lb.

TABLE II.—Increase, &c., of Sussex Sheep. Quantities in Pounds and Ounces.

Numbers.	Weights when put up, Nov. 7.	Increase in 4 Weeks, up to Dec. 5.	Increase in 4 Weeks, up to Jan. 2.	Increase in 4 Weeks, up to Jan. 30.	Increase in 4 Weeks, up to Feb. 27.	Wool shorn, March 27.	Increase (including wool) in 4 Weeks, up to Mar. 27.	Increase in 4 Weeks, up to April 24.	Increase in 2 Weeks, up to May 8.	Total Increase in 26 Weeks (inclusive of wool), up to May 8.	Average gain per Week of each Animal.	Final Weight, May 8, and wool.	Final Weight, May 8, (without wool.)
	lbs.	lbs.	lbs.	lbs.	bs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs. ozs.	lbs.	lbs.
1	87	12	7	6	7	6½	6½	10	5	53½	2 1	140½	134
2	97	12	11	6	11	6½	8½	12	6	66½	2 9	163½	157
3	99	12	13	5	9	6¼	6¼	14	9	68¼	2 10¼	167¼	161
4	89	5	4	10	11	5¼	6¼	11	6	53¼	2 0¾	142¼	137
5	86	8	4	5	5	6¼	5¼	11	2	40¼	1 8¾	126¼	120
6	84	7	6	3	5	5½	9½	10	5	45½	1 12	129½	124
7	87	10	8	5	10	6	4	8	6	51	1 15¾	138	132
8	86	8	8	3	8	5¼	2¼	4	2	35¼	1 5¾	121¼	116
9	96	13	5	4	4	6¾	2¾	13	7	48¾	1 14	144¾	138
10	102	14	10	7	6	6½	4½	9	11	61½	2 5¾	163½	157
11	96	11	6	6	10	5	2	11	7	53	2 0½	149	144
12	89	10	7	5	7	5¾	1¾	18	8	56¾	2 3	145¾	140
13	88	11	4	7	11	5¼	8¼	9	6	56¼	2 2½	144¼	139
14	84	5	10	5	8	5¾	7¾	8	5	48¾	1 14	132¾	127
15	88	13	5	4	7	5¼	4¼	8	8	49¼	1 14¼	137¼	132
16	82	10	6	7	6	5¾	6¾	14	6	55¾	2 2¼	137¾	132
17	93	14	3	8	9	6½	9½	10	6	59½	2 4¾	152½	146
18	80	10	11	3	7	5	7	10	4	52	2 0	132	127
19	82	7	9	6	9	6½	5½	10	8	54½	2 1½	136½	130
20	81	10	10	4	10	4½	1½	8	6	49½	1 14½	130½	126
21	95	10	7	2	7	5¼	0¼	15	7	48¼	1 13¾	143¼	138
22	79	12	8	6	5	5¾	4¾	12	7	54¾	2 1¾	133¾	128
23	91	8	2	7	9	4¼	3¼	11	6	46¼	1 12½	137¼	133
24	89	7	9	8	9	5½	2½	14	5	54½	2 1½	143½	138
25	84	10	8	6	10	5¼	2¼	17	6	59¼	2 4½	143¼	138
26	78	8	3	4	9	4½	2½	12	5	43½	1 10¼	121½	117
27	91	4	3	8	8	6¼	5¼	14	9	51¼	1 15½	142¼	136
28	80	19	6	4	10	4¾	4¾	9	10	62¾	2 6¾	142¾	138
29	93	12	5	7	6	5½	5½	9	8	52½	2 0½	145½	140
30	92	6	5	1	10	5	7	12	6	47	1 13	139	134
31	88	7	5	2	9	6	7	10	4	44	1 11	132	126
32	84	11	9	8	11	6½	2½	15	7	63½	2 7	149½	143
33	96	17	9	6	9	5½	6½	3	7	57½	2 3½	153½	148
34	85	10	8	5	4	6½	4½	13	9	53½	2 1	138½	132
35	86	11	3	4	8	5¾	9¾	12	6	53¾	2 1¼	139¾	134
36	93	9	6	4	8	5¼	4¼	12	9	52¼	2 0	145¼	140
37	85	15	6	7	11	5	2	9	6	56	2 2½	141	136
38	84	11	9	5	8	5½	2½	17	3	55½	2 2¼	139½	134
39	83	12	6	6	8	6½	5½	12	9	58½	2 4	141½	135
40	88	2	6	3	9	4½	0½	10	5	35½	1 5¾	123½	119
Totals . . .	3520	403	270	212	328	225	193	446	257	2109		5631	5406
Means & Average Weekly Gain per head during each period.	Mn. per head 88 lb.	lb. oz. 2 8	lb. oz. 1 11	lb oz. 1 5⅕	lb. oz. 2 1	Mn. per head 5 lb. 10 oz.	lb. oz. 1 3¼	lb. oz. 2 12⅗	lb. oz. 1 9½	Mn. per head 52·75 lb.	lb. oz. 2 0½	Mn. per head 140·75 lb.	Mn. per head 135·15 lb.

In a former paper on Sheep-feeding, in this Journal, we particularly directed attention to the great variation in the rate of increase in the same animal at different periods, and also of different animals on the same food, however carefully selected with regard to quality and uniformity. It is, perhaps, seldom that animals have been drawn for purposes of experiment with more care than in the instances of which the foregoing tables record the results, yet we have scarcely a sheep in either breed which does not give twice, thrice, or more times as great an increase in gross live weight at one period, as at another of equal length; whilst, taking the entire period of the experiment, we have nearly double the increase with some animals as with others by their side, and having ostensibly the same description and qualities of food provided.

The variation in the apparent rate of gain of the same animal at different times, is largely due to the difference in the amounts of the matters of the food retained within the animal at the different times of weighing, and to obviate error from this cause we have only to extend our experiments over a sufficient length of time, and to be careful, as far as possible, always to weigh the animals at the same period of the day, and under similar circumstances as regards their hours of feeding.

With respect to the difference of result shown by different animals, having professedly the same allowance of food, much of it is doubtless due to distinct constitutional tendency to fatten or otherwise; yet in some cases it no doubt depends upon a real difference in the food consumed by individual animals, for it is impossible to secure for each its due share of the several foods supplied; and wherever there are many animals kept and fed together, there are always some who exercise a kind of mastery over the rest, and if they do not eat more food altogether than is allotted to them, they will at least take more of the best of it than is their share, and thus reduce the fair allowance to all the rest. By this cause, indeed, it is not improbable that the proper feeding and increase of some animals well adapted for it may be prevented; though in so far as these differences are really due to the quantities of food consumed by different individuals, it is obvious that the true relation of food to increase will be less misstated by the gross numerical results of feeding experiments, than would be the case were the irregularities entirely owing to varying constitutional capabilities of the different animals to grow or fatten upon the same food.

But whatever be the causes of these variations, the figures in the tables show that, notwithstanding the careful selection of the animals, we have among the Hampshire sheep a difference in their average weekly gain of from about $3\frac{3}{4}$ lbs. to little more

than 2 lbs.; and among the forty Sussex sheep, of from little more than $2\frac{1}{2}$ lbs. to less than $1\frac{1}{2}$ lb. Indeed the tenor of all published results on feeding, seems to show that these fluctuations and variations are the rule and not the exception; and the fact of them, therefore, should lead us to great caution in drawing nice conclusions from experiments made with but a small number of animals, and extending only over a short period of time. We think, however, that the general results of experiments with forty sheep in each lot, and carried on for a period of 26 weeks, cannot be considered as open to serious objection on account of these irregularities.

With these remarks as to the degree of reliance which we believe our results may fairly claim, little further comment is necessary upon these tables of mere detail; but we would suggest in passing—besides a glance along and across the columns to show the fluctuations alluded to—an inspection of the columns showing the quantities of wool obtained from each sheep of the two breeds respectively, and also, that the reader should carry his eye down the column (No. 12) of each of the tables, showing the *average weekly gain of each animal*, and also along the bottom lines, wherein are given the *average weekly gain per head of the forty sheep* during the several—chiefly monthly—periods of the experiment; he will thus, by an easy view, gather a pretty clear conception of the average rates of gain of the two breeds respectively.

In the six following tables are given, for the two lots of sheep respectively:—

In Table III., the *total food* consumed, and *total increase* produced, between each weighing.

In Table IV., the quantities of *food consumed to produce* 100 *lbs. increase* in live weight.

In Table V., the *food consumed per head* weekly.

In Table VI., the *food consumed per* 100 *lbs. live weight* weekly.

In Table VII., the *average increase in weight per head* weekly.

And in Table VIII., the *average increase in weight per* 100 *lbs.* weekly.

TABLE III.

Showing the Description and Quantities of Food consumed, and of Increase produced by each lot of Sheep, between each interval of weighing; chiefly monthly periods.

(Quantities given in Pounds.)

Periods.	Length of Time.	Oilcake.		Clover Hay.		Swedes.		Increase in Live Weight.	
		Hampshire.	Sussex.	Hampshire.	Sussex.	Hampshire.	Sussex.	Hampshire.	Sussex.
	Weeks.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Between Nov. 7 and Dec. 5	4	1120	868	1120	868	14,000	11,034	429	403
,, Dec. 5 ,, Jan. 2	4	1120	868	1120	868	13,693	10,772	385	270
,, Jan. 2 ,, Jan. 30	4	1120	868	1120	868	15,476	11,186	382	212
,, Jan. 30 ,, Feb. 27	4	1120	868	1120	868	18,422	12,133	445	328
,, Feb. 27 ,, Mar. 27	4	1120	868	1120	868	18,278	12,312	462¾	193
,, Mar. 27 ,, Apr. 24	4	1680	1288	1120	1120	21,616	15,820	388	446
,, Apr. 24 ,, May 8	2	840	644	560	560	8,982	7,640	293	257
Total Increase of 40 Sheep in 26 weeks	26	8120	6272	7280	6020	110,467	80,897	2784¾	2109
Average food consumed, and increase produced by 40 Sheep in 4 weeks	..	1249	965	1120	926	16,995	12,445	428	324

TABLE IV.

Showing the Quantities of Food consumed during each period to produce 100 lbs. Increase in live weight, by each lot of Sheep.

(Quantities given in Pounds and Ounces.)

Periods.	Length of Time.	Oilcake.		Clover Hay.		Swedes.	
		Hampshire.	Sussex.	Hampshire.	Sussex.	Hampshire.	Sussex.
	Weeks.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs.	lbs.
Between Nov. 7 and Dec. 5	4	261 1	215 6	261 1	215 6	3263	2738
,, Dec. 5 ,, Jan. 2	4	290 15	321 8	290 15	321 8	3556	3990
,, Jan. 2 ,, Jan. 30	4	293 3	409 6	293 3	409 6	4051	5276
,, Jan. 30 ,, Feb. 27	4	251 11	264 6	251 11	264 6	4140	3699
,, Feb. 27 ,, Mar. 27	4	241 8	449 12	241 8	449 12	3941	6379
,, Mar. 27 ,, Apr. 24	4	433 0	288 15	288 11	251 2	5571	3547
,, Apr. 24 ,, May 8	2	286 11	250 9	191 2	217 14	3065	2973
Average for the entire period of the Experiment . . .	26	294 0	314 4	259 12	304 3	3941	4086

Table V.

Showing the Average Weekly Consumption of Food *per Head* for each period of the Experiment. (Quantities given in Pounds and Ounces.)

Periods.	Length of Time.	Oilcake.		Clover Hay.		Swedes.	
		Hampshire.	Sussex.	Hampshire.	Sussex.	Hampshire.	Sussex.
	Weeks.	lbs.	lbs. oz.	lbs.	lbs. oz.	lbs. oz.	lbs. oz.
Between Nov. 7 and Dec. 5	4	7	5 7	7	5 7	87 8	69 0
,, Dec. 5 ,, Jan. 2	4	7	5 7	7	5 7	85 9	67 5
,, Jan. 2 ,, Jan. 30	4	7	5 7	7	5 7	96 12	69 15
,, Jan. 30 ,, Feb. 27	4	7	5 7	7	5 7	115 2	76 0
,, Feb. 27 ,, Mar. 27	4	7	5 7	7	5 7	114 4	77 0
,, Mar. 27 ,, Apr. 24	4	10½	8 0	7	7 0	135 2	98 15
,, Apr. 24 ,, May 8	2	10½	8 0	7	7 0	112 4	95 8
Average for the entire period of the Experiment	26	8	6 3	7	5 14	106 10	79 1

Table VI.

Showing the Average Weekly Consumption of Food *per 100 lbs. live Weight* of Animal for each period of the Experiment.

(Quantities given in Pounds and Ounces.)

Periods.	Length of Time.	Oilcake.		Clover Hay.		Swedes.	
		Hampshire.	Sussex.	Hampshire.	Sussex.	Hampshire.	Sussex.
	Weeks.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Between Nov. 7 and Dec. 5	4	5 14¼	5 13¼	5 14¼	5 13¼	73 10¼	74 2
,, Dec. 5 ,, Jan. 2	4	5 6¾	5 5½	5 6¾	5 5½	66 5¾	66 5¾
,, Jan. 2 ,, Jan. 30	4	5 1	5 0¾	5 1	5 0¾	69 13	65 0¾
,, Jan. 30 ,, Feb. 27	4	4 11¼	4 12	4 11¼	4 12	77 5¼	66 6½
,, Feb. 27 ,, Mar. 27	4	4 7	4 8	4 7	4 8	71 4½	63 11¾
,, Mar. 27 ,, Apr. 24	4	6 2¼	6 4	4 1½	5 7	79 1	76 13
,, Apr. 24 ,, May 8	2	5 13¾	5 13½	3 14½	5 1½	62 9½	69 7¼
Average for the entire period of the Experiment . . .	26	5 6	5 6	4 12¾	5 2	71 7	68 14

Table VII.

Showing the Average *Weekly Increase per Head* during each period of the Experiment.

(Quantities given in Pounds and Ounces.)

Periods.	Length of Time.	Hampshire.	Sussex.
	Weeks.	lbs. oz.	lbs. oz.
Between Nov. 7 and Dec. 5	4	2 11	2 8¾
,, Dec. 5 ,, Jan. 2	4	2 6½	1 11
,, Jan. 2 ,, Jan. 30	4	2 6	1 5
,, Jan. 30 ,, Feb. 27	4	2 12½	2 0¾
,, Feb. 27 ,, Mar. 27	4	2 14	1 3¼
,, Mar. 27 ,, Apr. 24	4	2 6½	2 12½
,, Apr. 24 ,, May 8	2	3 10½	3 3½
Average for the entire period of the Experiment . . .	26	2 12	2 1¾

Table VIII.

Showing the Average *Weekly Increase per* 100 *lbs. live Weight* for each period of the Experiment.

(Quantities given in Pounds and Ounces.)

Periods.	Length of Time.	Hampshire.		Sussex.	
	Weeks.	lbs.	oz.	lbs.	oz.
Between Nov. 7 and Dec. 5	4	2	4	2	$11\frac{1}{4}$
,, Dec. 5 ,, Jan. 2	4	1	$13\frac{3}{4}$	1	$10\frac{1}{2}$
,, Jan. 2 ,, Jan. 30	4	1	$11\frac{1}{4}$	1	$3\frac{1}{4}$
,, Jan. 30 ,, Feb. 27	4	1	14	1	13
,, Feb. 27 ,, Mar. 27	4	1	13	1	0
,, Mar. 27 ,, Apr. 24	4	1	$7\frac{3}{4}$	2	$2\frac{1}{2}$
,, Apr. 24 ,, May 8	2	2	$0\frac{3}{4}$	1	$2\frac{3}{4}$
Average for the entire period of the Experiment . . .	26	1	14	1	$10\frac{3}{4}$

Note.—It may aid the reader in gaining a clearer idea of the plan and object of Tables IV., VI., and VIII., and assist in his understanding of their results, if the following illustration of the mode in which they are obtained be added.

In Table IV., and during the first period of 4 weeks, between November 7th and December 5th, it will be seen that the Hampshire sheep are said to consume 261 lbs. 1 oz. of oil-cake, 261 lbs. 1 oz. of clover-hay, and 3263 lbs. of swedes, to produce 100 lbs. increase in live weight. Now, in Table III. it will be found that during the same period there were consumed 1120 lbs. of oil-cake, and that the increase obtained amounted to 429 lbs. Then we say—

```
     Increase.  Oilcake.             lbs.
As     429   :   1120   ::   100  :  261
                  100
              --------
      429 )    112000  ( 261 lbs. of oil-cake consumed to produce
                  858               100 lbs. of increase in live weight.
               ------
                 2620
                 2574
               ------
                   460
                   429
                  ----
                    31
```

The 261 lbs. 1 oz. of clover-hay is obtained in the same way, thus:—

Increase. Clover. lbs.
As 429 : 1120 :: 100 : 261 of clover consumed to produce 100 lbs. of increase in live weight.

And so with the swedes:—

Increase. Swedes. lbs.
As 429 : 14,000 :: 100 : 3263 of swedes consumed to produce 100 lbs. of increase in live weight.

In the same way like results are obtained for all the other periods.

In Table VI. we find that the Hampshire sheep during the first period, between November 7th and December 5th, are said to consume weekly 5 lbs. $14\frac{1}{4}$ oz. of oil-cake, 5 lbs. $14\frac{1}{4}$ oz. of clover-hay, and 73 lbs. $10\frac{1}{4}$ oz. of swedes, for every 100 lbs. of their weight during the same period. To determine the weight of the forty Hampshire sheep during this first period, their weight at the beginning of it—which is 4538 lbs.—is added to their weight at the end of it, viz. 4967 lbs., and gives 9505 lbs., and then this sum divided by 2 gives 4752·5, which is considered to be the *mean* weight of the 40 Hampshire during the first period. It is this mean weight of 4752·5 lbs. that is supposed to consume the 1120 lbs. of oil-cake, 1120 lbs. of clover-hay, and 14,000

In Table III. we have the total food consumed and the total increase by each lot of 40 sheep between each period of weighing, and, as might be expected from the very different weights of the animals of the two breeds respectively, the amounts, both of food and increase within a given time, are always much greater in the case of the Hampshire than in that of the Sussex sheep. But from the results as arranged in this Table it cannot be ascertained in which of the two breeds a given amount of food has produced

---

lbs. of swedes, before referred to, as given in Table III.; and to bring these quantities to a weekly period, instead of a monthly one, we have only to divide each of them by 4. Then we say:—

Mean weight. Oilcake. lbs. oz.

As 4752·5 : 280 :: 100 : 5 $14\frac{1}{4}$

100

4752·5) 28000·0 (5 lbs. $14\frac{1}{4}$ oz. oil-cake consumed weekly per 100 lbs. live weight of animal.

237625

42375

16

4752·5) 678000 ($14\frac{1}{4}$

47525

202750

190100

12650

In the same way we say—

Mean weight. Clover. lbs. oz.

As 4752·5 : 280 :: 100 : 5 $14\frac{1}{4}$ of clover consumed per 100 lbs. live weight of animal.

And so on with the swedes—

Mean weight. Swedes. lbs. oz.

As 4752·5 : 3500 :: 100 : 73 $10\frac{1}{4}$ of swedes consumed per 100 lbs. live weight of animal.

And so on for the other periods.

In Table VIII. the Hampshire sheep are said to give a weekly increase in weight of 2 lbs. 4 oz. upon each 100 lbs. of their weight, during the first period, elapsing between November 7th and December 5th. To get this result the same mean weight is used as before, and the increase during this period, viz. 429 lbs., is divided by 4 to bring out the result per week, instead of per month. Then we say:—

Mean weight. Increase. lbs. oz.

As 4752·5 : 107·25 :: 100 : 2 4 = the weekly increase per 100 lbs. live weight of animal.

100

4752·5) 10725·00 (2

95050

12200

16

4752·5) 195200 (4

190100

And the results for the other periods are obtained in the same way. We have given our methods of preparing these Tables in detail, as we think it would be advantageous for others, who are engaged in feeding experiments, to employ them.

the greater increase; or, what is the same thing, in which case a given quantity of increase is obtained at the cost of the least consumption of food. This important point is brought clearly to view in Table IV., but before passing to the consideration of it, it will be well to make one or two remarks on some points which are sufficiently obvious in Table III.

It has before been said that the dry foods were allotted to the two breeds in fixed quantities, exactly in proportion to the weight of animals in each respectively, and hence the uniformity in the quantities of oil-cake and clover consumed during most of the monthly periods. It will be seen, however, that during the period commencing with March 27th, when the animals were shorn, the quantity of *oil-cake* is increased to both lots by one half the previous allowance. This it was thought well to do as the animals progressed; but by the mistake of the attendant the ration of clover also was increased to the Sussex sheep at the same time by being made equal to that of the Hampshires; and it is remarkable, as shown in the last two columns of the Table, that in this period of an excess of clover in favour of the Sussex sheep, they gave a higher increase than the Hampshires, though they did so at no other period of the experiment. It should at the same time be noticed that, in the period immediately preceding this, the one of more than usual increase in the Sussex sheep, they had gained much less than their average amount, so that much of the subsequent higher rate of gain may in reality be considered as only compensatory, rather than as due entirely to the increased allowance of clover. Indeed, the results of these two consecutive periods afford a striking instance of the fluctuations in the apparent progress of animals, as indicated by their weight taken at short intervals of time.

A glance at the columns giving the swedes consumed will show that there was with both breeds a gradual increase in the quantity eaten as the experiment proceeded; and it is remarkable too, that this increase in the amount of swedes is in both cases much greater in the period commencing March 27th, when the animals lost their wool, than at any other time during the course of the experiment, notwithstanding that it was at this period that the allowance of dry food was also considerably increased. The increased consumption during the other periods is probably in some part due to a depreciation in the quality of the turnips as the season advanced, and not to be attributed entirely therefore to the increased requirements of the animals. They would, it is true, probably require more *per head* as they increased in size and weight, but not proportionally to their increase of weight, for we shall presently see, on reference to Table VI., that, excepting immediately after the animals lost their wool, the quantity con-

sumed *per* 100 *lbs. live weight* was rather lessened than increased as the experiment advanced and the sheep approached maturity.

Turning now to Table IV. we have a view of the *comparative productive effects* of the food in the two cases, during the different periods, so far as the fluctuating weights of the animals during such short intervals can be taken as the basis upon which to calculate it; but a glance down the columns of the Table will show that no single period could be taken in itself as giving a fair point of comparison between the two breeds in this respect.

It is seen that in some of the intervals the Sussex sheep consumed the least food to produce a given quantity of increase, but in the majority of the cases the Hampshires had the advantage; and the final result, as shown in the bottom line of the Table, is, that to produce 100 lbs. increase of live weight the Sussex sheep required $20\frac{1}{4}$ lbs. more oil-cake, $42\frac{1}{2}$ lbs. more clover chaff, and 145 lbs. more swedes than the Hampshires. This is shown in the summary of Table IV. given below; but it remains to be seen as we proceed whether the increase of the Sussex sheep was of such an increased value as to compensate for this greater quantity of food required to produce it.

TABLE IX.

Showing the average Food consumed to produce 100 increase during the entire period of 26 Weeks.

—	Oil Cake.		Clover.		Swedes.
	lbs.	oz.	lbs.	oz.	lbs.
Sussex	314	4	304	3	4086
Hants	294	0	259	12	3941
More food required by Sussex sheep	20	4	44	7	145

In Table V. are given the average quantities of food consumed *per head* weekly during each period of the experiment, and of course the same relationship of figures will here be found as in Table III., wherein are given the quantities consumed by 40 sheep per month; but the lessened numbers in Table V. will be more easily studied. However, some of the chief points of interest embodied in the facts of this Table are more clearly brought out in Table VI., immediately succeeding it, in which are given the quantities consumed weekly *per* 100 *lbs.* instead of *per head.* Contrasting, however, the results of the two Tables V. and VI., we find, as has already been alluded to, that although there is with both breeds something like a constant increase in the amount of food consumed *per head* as the experiment pro-

ceeded, yet, excepting immediately after the animals had lost their wool, there is a disposition to decrease rather than increase in the rate of consumption of food, when calculated *per* 100 *lbs. weight* of animal, instead of per head.

Comparing now one breed with the other, we find that the two lots consumed very different quantities of food per head weekly, but the quantities consumed weekly per 100 lbs. are, as given in Table VI., almost identical for the two breeds. Thus, taking the average of the entire period of the experiment, as given in the bottom line of Table VI. we have, both for Hampshire and Sussex, the same amount of oil-cake consumed per 100 lbs. per week, of clover 5 ounces more, and of turnips $2\frac{1}{2}$ lbs. less by the Sussex sheep than by the Hampshire;—quantities which, when the great difference in the proportions of water contained in these two foods is considered, may be calculated as yielding almost identical quantities of solid food to the animals, and therefore, as for all practical purposes, neutralising each other. As has already been said, the swedes were in both cases given *ad libitum,* thus allowing the animals to fix their own limits of consumption according to the requirements of the system; we conclude, therefore, that the natural requirements, whatever they may be, are, under equal circumstances, the same for both breeds. It may be interesting here to observe, that numerous experiments on the feeding of the various animals kept upon the farm clearly show that this natural limit of consumption, as fixed by the animals themselves, is determined far more by the amount supplied in the food of those constituents which are termed the respiratory and fat-forming principles, than by that of the nitrogenous ones. Indeed, we have frequently found that whilst in a set of comparative experiments the quantity consumed of the former has been all but identical in the different cases, that of the latter has varied as much as from one to two, or more.

But we must not enter further into this interesting question in this place, though we have many facts relating to it which we hope to publish shortly, in connection with the subject of feeding generally.

From Table VI. we have learnt, then, that the Hampshire and Sussex sheep consumed identical quantities of food in relation to their weight; but in Table IV. we have seen that the Hampshire sheep gave more increase for this food than the Sussex, for in producing 100 lbs. of increase the Sussex has consumed nearly 7 per cent. more oil-cake, $17\frac{1}{4}$ per cent. more clover, and $3\frac{3}{4}$ per cent. more swedes than the Hampshires.

In Table VII. we have the average weekly gain *per head* of the two breeds, and it is worthy of remark that these sheep, of superior quality, as those of both breeds undoubtedly were, of

their kind, supplied with a liberal allowance of food, and protected from the weather, should, in neither case, reach an average gain of 3 lbs. per head per week, that of the Hampshires being $2\frac{3}{4}$ lbs. and that of the Sussex scarcely 2 lbs. 2 oz. By this remark we do not mean to imply that the result is less than was to be expected; on the contrary, we believe the animals in both cases to have done exceedingly well, more so indeed than is usual; but we wish to fix the attention of the reader upon these quantities, because we know that many entertain exaggerated opinions as to the rate of increase of fatting sheep, which closer attention to weights, and extending their trials to a greater number of animals, and over longer periods of time, would, we are persuaded, dissipate.

But as to this point of average weekly gain, like those already discussed, a clearer conception will be gathered where the quantity is given *per* 100 *lbs.* weight of animal instead of per head. This is done in Table VIII.

In Table VIII., then, we see that in the case of neither breed have we an average increase, for the entire period, of two per cent. per week upon the weight of animal; that upon the 100 lbs. being for the Hampshires only 1 lb. 14 oz., and for the Sussex sheep only 1 lb. $10\frac{3}{4}$ oz.! A glance down the columns of the Table will show indeed for both lots of sheep, that during the whole period of the experiments, they reached but twice an increase of 2 per cent. per week. One of these periods of high gain was, in the case of both breeds, at the very commencement of the experiment, when therefore the change from store to fatting food was likely to show more than an average result; the other instance of high gain in the Sussex sheep was at the time of the increased quantity of clover; with the Hampshire it was during the last fortnight of the experiment, and was then only 2 lbs. $0\frac{3}{4}$ oz.; whilst the high increase of the Sussex sheep in the previous period, was in the next reduced to only 1 lb. $2\frac{3}{4}$ oz.

To repeat—with neither breed was there an increase of 3 lbs. per head per week during the fatting process, and with neither was there a weekly increase of 2 per cent. on the live weight, that on the Hampshires being 1 lb. 14 oz., on the Sussex only 1 lb. $10\frac{3}{4}$ oz.; in favour, therefore, of the Hampshire sheep in this respect by $3\frac{1}{4}$ oz., or about one-eighth of the whole amount.

The next point of comparison between the two breeds is as to the amounts of wool obtained from each.

The quantities of wool shorn from each individual sheep are given for the two breeds respectively in Tables I. and II., but a summary of the figures of those Tables is here brought to view:—

TABLE X.

—	Total Amount from the 40 Sheep.	Average, per Head.		Proportion of Wool to 100 Live Weight of Animal.
	lbs.	lbs.	oz.	
Wool shorn from the Hampshires, March 27 . .	$250\frac{3}{4}$	6	4	3·77
Ditto Sussex, March 27 .	225	5	10	4·57
Difference . .	$25\frac{3}{4}$	0	10	0·80

The larger sheep, the Hampshire, gives then an average of $6\frac{1}{4}$ lbs. of wool per head, and the smaller one, the Sussex, 5 lbs. 10 oz. If, however, we consider these quantities in relation to the weights of the animals at the time they were shorn respectively, we see, as in the 3rd column of the Table, that the Hampshire, though probably by some weeks an older sheep, gives only 3·77 per cent., or $3\frac{3}{4}$ lbs. of wool per 100 lbs. weight of animal, whilst the Sussex gives 4·57 per cent., or rather more than $4\frac{1}{2}$ lbs. of wool upon every 100 lbs. live weight. The quality of the wool of the Sussex sheep is also rather superior to that of the Hampshire, but to this point we shall presently recur.

The result is, then, that the Sussex sheep, with a live weight of only about three-fourths that of the Hampshire, has given nine-tenths as much wool, which is equivalent to one-fifth more wool yielded by the Sussex sheep upon an equal live weight of animal.

It is said that although the Sussex sheep does not come so early to maturity as the Hampshire, yet, when fit for the butcher, not only does it give a larger proportion of carcass and less of offal, but that the price of the meat is higher, and also that of the wool, and sufficiently so to compensate for any disadvantages in other respects. But before entering upon the question of the money result of the experiment, we will give the particulars of the proportions of carcass and of loose fat, &c., of some of the animals, which were killed at home with a view of deciding upon the comparative qualities of the two breeds in these respects.

It was our object, indeed, so to complete the experiment that, as far as possible, it should include a comparison of the degree of maturity of the animals, and the money result up to the time to which we have already brought this Report, and also give some information as to the relative productive qualities of the two breeds under a more lengthened course of feeding. With this view it was determined to kill 16 of each lot at home, and send the carcasses to Newgate Market—to send 16 of each alive to Smithfield, and to feed the remaining 8 of each until Christmas.

The selection of the animals so as satisfactorily to meet the points, as above described, was somewhat difficult, but the plan adopted was as given below.

With respect to the first lot of 16 of each breed to be killed at home, the object was to draw those animals for this purpose which had shown the two extremes as to rate of increase, as well as some which seemed to have the average qualities of the breed to which they belonged in this respect. Those taken were therefore—

The 4 of largest increase;

The 4 of smallest increase; and,

The 8 which had given an increase nearest the average of the 40.

The 16 to be sold alive comprised the 8 of the next largest and the 8 of the next smallest increase to those of the two extreme lots, just mentioned.

And the 8 to be fed on till Christmas* were the 4 of the next larger and the 4 of the next smaller increase to those allotted as last described, so that these sheep were intermediate in point of rate of increase between the 16 to be sold alive and the 8 of medium increase to be killed at home.

The following summary will show to what extent this method of selection gave a fair average of quality in each lot as to increase, and produce of wool:—

TABLE XI.

	Increase per Head including Wool.		Wool per Head (Shorn March 27)		Original Weight November 7.		Final Weight May 8, without Wool.	
	Hants.	Sussex.	Hants.	Sussex.	Hants.	Sussex.	Hants.	Sussex.
	lbs.	lbs.	lbs. oz.	lbs. oz.	lbs.	lbs.	lbs.	lbs.
Mean of the 16 killed at home	71·5	52·8	5 15½	5 10	113·3	88·5	178 9	136·2
Mean of the 16 sold alive	68·1	52·5	6 8	5 10	113·2	89·8	174·2	137·0
Mean of the 8 to be fed till Christmas . . .	68·5	53·0	6 6	5 10	114·2	83·2	176·4	130·6
Mean of the 40 Hants and Sussex	69·5	52·7	6 4	5 10	113·4	88·0	176·5	135·4

It would be difficult to devise a method of selection which should give, both within each lot, and between lot and lot of each breed, the average qualities possessed by the whole; but taking

* At the time we are correcting for the press (October 1851) the trial in reference to these animals is of course not yet completed, so that the results must be reserved for some future occasion.

as our ground of selection the point of the rate of increase, which is certainly an important character in a fatting animal, we have at least, as regards this point, obtained a considerable degree of uniformity in the average of each lot, as compared with that of the whole. The chief exception is the first lot of the Hampshires, and the high average weight of increase here seen is due to the excessive rate of gain of the 4 largest animals of this breed; and, as will be seen, the selection according to increase, which has thus drawn out these animals for killing, has satisfactorily led to an explanation of their comparatively rapid gain in weight. Three out of the four of them were, indeed, what are termed "riggs," or were only half-castrated, and hence they grew in frame enormously. They would, doubtless, be masters of all the other sheep, and always secure the lion's share of food, or at least make whatever selection of it they chose.

Another benefit of the mode of selection adopted was, that as *rate of increase* is really the great question at issue, we by this means secured for killing at home, and taking the weights of all the parts, those animals in which the maximum, the minimum, and the mean tendency to increase had been manifested, so that if there were any clearly defined connection between the rate of increase on the one hand, and the relation of dead weights to live on the other, this seemed likely to be brought to light in the results.

In the following Table are given some of the main particulars of the animals whilst alive, by the side of those obtained on killing them:—

Table XII.

Numbers of the Sheep.		WEIGHTS ALIVE. Increase per Head in 26 Weeks, to May 8 (including wool).		Wool per Head, shorn March 27. Pounds & ounces.		Original Weights, November 7, 1850.		Final Live Weight, May 8, in Pounds, and without Wool. Hants.		Sussex.		WEIGHTS DEAD. Carcass 28 to 36 hours after Killing.		Proportion of Cold Carcass in 100 Unfasted Weight.		Proportion of Cold Carcass in 100 Fasted Weight.		Proportion of Loose or Inside Fat in 100 Fasted Weight.		Proportion of Lungs and Windpipe in 100 Fasted Weight.	
Han's.	Sussex.	Hants.	Sussex.	Hants.	Sussex.	Hants.	Sussex.	Not Fasted.	Fasted.	Not Fasted.	Fasted.	Hants.	Sussex.	Hants.	Sussex.	Hants.	Sussex.	Hants.	Sussex.	Hants.	Sussex.
		lbs.	lbs.	lbs. ozs.	lbs. ozs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs. ozs.	lbs. ozs.								
8	3	99½	68¼	5 8	6 4	119	99	213	197	161	148	117 14½	91 9	55·36	56·87	59·85	61·87	6·525	7·383	0·935	0·872
3	2	96½	66½	5 8	6 8	124	97	215	200	157	145	121 9	92 14	56·54	59·16	60·78	64·05	6·864	6·889	0·881	0·804
32	32	95½	63½	6 8	6 8	112	84	201	186	141	131	116 13½	77 15	58·13	55·27	62·82	59·49	6·417	7·153	0·715	0·898
38	28	88	62¾	8 0	4 12	116	80	196	183	138	128	112 9¼	79 2	57·44	57·34	61·52	61·82	6·348	6·890	0·828	0·982
Mean of 4 largest.		94 4	65 4	6 6	6 0	117 12	90	206 4	191 8	149 4	138	117 3½	85 6	56·87	57·16	61·24	61·81	6·538	7·078	0·840	0·889
15	8	54	35¼	6 0	5 4	105	86	153	145	116	112	85 2	67 4	55·64	57·97	58·71	60·04	8·323	8·305	1·035	0·986
36	40	54¾	35½	5 12	4 8	96	88	145	135	119	112	79 2	67 4½	54·57	56·54	58·61	60·07	5·443	5·714	1·237	1·100
2	5	55¼	40½	4 4	6 4	119	86	170	160	120	113	98 2½	65 10	57·74	54·69	61·35	58·07	8·623	8·028	0·970	1·100
30	26	55½	43½	7 8	4 8	105	78	153	144	117	112	88 5	66 0	57·72	55·41	61·33	58·93	6·992	6·641	0·892	1·009
Mean of 4 smallest.		54 14	38 10	5 14	5 2	106 4	84 8	155 4	146	118	112 4	87 10¾	66 8½	56·42	56·15	60·00	59·28	7·345	7·172	1·034	1·049
14	24	69¼	54½	5 8	5 8	108	89	172	163	138	134	98 0	78 10	56·98	56·98	60·12	58·68	7·864	7·124	1·057	1·228
7	11	60¼	54	6 4	5 0	125	96	188	178	144	137	107 4½	84 10½	57·06	58·79	60·27	61·79	6·299	8·957	0·797	1·144
33	35	69	53¾	7 0	5 12	108	86	170	157	134	127	93 4	76 8	54·85	57·09	59·39	60·24	7·432	8·687	1·010	0·932
34	1	68½	53½	5 8	6 8	113	87	176	168	134	128	103 12½	77 9½	58·97	57·91	61·77	60·62	8·520	7·319	0·821	0·860
21	34	68½	53½	6 8	6 8	131	85	193	182	132	123	109 10	74 7½	56·80	56·41	60·23	60·54	7·543	5·907	0·912	1·082
39	4	68	53¼	6 0	5 4	100	89	162	150	137	131	92 9	78 8½	57·13	57·32	61·71	59·95	6·226	6·353	1·022	1·023
19	29	67½	52½	5 8	5 8	120	93	182	171	140	132	104 0½	80 5½	57·16	57·32	60·84	60·87	6·053	8·128	0·889	0·886
40	36	66½	52¼	4 8	5 4	112	93	174	159	140	130	96 13	80 7½	55·64	57·48	60·82	61·90	7·982	7·145	0·960	1·095
Mean of 8 medium.		68 6	53 7	5 13½	5 11	114 10	89 12¾	177 2	166	137 6	130 4	100 12	77 10	56·82	57·41	60·64	60·57	7·240	7·453	0·933	1·031
SUMMARY.																					
Mean of 4 largest inc.		94 4	65 4	6 6	6 0	117 12	90 0	206 4	191 8	149 4	138 0	117 3½	85 6	56·87	57·16	61·24	61·81	6·538	7·078	0·840	0·889
Mean of 4 smallest in.		54 14	38 10	5 14	5 2	106 4	84 8	155 4	146 0	118 0	112 4	87 10¾	66 8½	56·42	56·15	60·00	59·28	7·345	7·172	1·034	1·049
Mean of 8 medium in.		68 6	53 7	5 13½	5 11	114 10	89 12¾	177 2	166 0	137 6	130 4	100 12	77 10	56·82	57·41	60·64	60·57	7·240	7·453	0·933	1·031
Mean of the 16 killed.		71 7½	52 11	5 15½	5 10	113 5	88 8¼	178 15	167 6	135 8	127 11	101 14	76 13	56·73	57·03	60·63	60·56	7·091	7·289	0·935	1·000
Mean of the 40		69 9	52 12	6 4	5 10	113 7	88 0	176 13		135 0											

In the columns of increase the very great increase of the first three Hampshires, to which allusion has already been made, stands out prominently, and it amounts to an average of $3\frac{3}{4}$ lbs. per head per week.

In the case of both the breeds, the second lot, or the four of least increase, gave an amount of gain little more than half that of the lot preceding it. On the other hand, in the list of medium increase, the 8 of each breed give among themselves respectively almost identical amounts of increase. We have thus, as was desired, among the 16 animals chosen to be killed, great diversity as to rate of increase, though, as we have already seen, and as the summary at the bottom of the Table shows, an average not differing widely from the average of the 40. But it would seem that, so far as the particulars given in Table XII. can indicate it, the animals thus brought together in each lot as having increased at equal rates, had developed but few other distinctive characters in common. Thus, first taking a glance at the column giving the amounts of wool shorn from these animals which were drawn out for killing, we shall see a very great irregularity in its quantity per head within each of the lots of nearly equal rate of increase, and this remark applies pretty equally to both breeds; nor is the difference much less prominent among the 8 animals of great regularity as to rate of increase than with the two lots of 4 each, showing respectively extreme and opposite qualities in this respect. The differences are, however, not quite so marked among the 8 Sussex sheep of medium rate of increase as among the corresponding 8 of the Hampshire breed.

Next, as to the proportion of dead weight to live, whether we take the per-centage of carcass in the gross, or in the fasted live weight, we find in both breeds an almost equal irregularity among the animals of nearly equal increase; though in both breeds the differences are certainly less among the 8 animals of more average quality than with either of the other lots.

But if we take the mean results, as given at the foot of the Table, we see that the three lots respectively of largest, of smallest, and of medium increase give very nearly equal proportions of carcass; and, comparing the one breed with the other in this respect, we have a still nearer identity.

With regard to the point of inside or loose fat, it is remarkable that there is in both breeds as wide a range of difference among the 8 animals of medium and nearly equal rate of increase, as among the individuals of either of the other lots. The differences, indeed, in the proportion of inside fat are much greater between the individual animals of the several lots than between the averages either of the different lots of the same breed or of the different breeds. To this remark the 4 largest Hampshires are somewhat

exceptional, the individuals composing it giving very nearly equal proportions of loose fat, though the average for this lot is less than for any other; this indeed is quite consistent both with the appearance of these animals and with the known fact of their tendency to increase in frame rather than to fatten.

Taking the average of the 16 sheep in each case, we find the Sussex sheep have given more loose fat than the Hampshires by about 0·2 per cent., an amount which is really insignificant. Nevertheless, it is worthy of remark that the *direction* of this difference is quite consistent with that between the average proportion of lung found in the two cases. Thus we have in the Sussex a rather higher per-centage both of loose fat and of lung; characters which, when they predominate, bespeak more of the habit of exercise and a tendency to develop fat more rapidly around the abdominal viscera than upon the carcass; whilst the opposite characters are those which indicate an animal of less roaming habits and more accustomed and fitted to have an easy access to a liberal supply of good food, and with these, more of the tendency to increase in carcass, and less in the alimentary organs and the fat surrounding them, These qualities in fact are those of "*early maturity;*" and it is certainly a great desideratum in a fatting animal to attain the necessary ripeness of meat with as little expenditure as possible of time and food in the production of mere inside fat or tallow, to the profit of the butcher.

It is true that our experiments have shown very slight differences between the two breeds in relation to the points in question, yet still the *direction* of those differences is consistent with the current opinions on the subject in reference to the two breeds, viz., that the Hampshire sheep comes earlier to maturity, and that the Sussex, when ripe, gives more valuable offal to the butcher.

That there is some general connection between relative smallness of lung and of loose fat on the one hand, and tendency to increase on the other, is further seen on comparing the different lots of the same breed with one another in the summary at the foot of the Table; for we there see that with both breeds the smallest proportion both of lung and of loose fat was in the lots of largest increase. With regard to lung the converse is also true, for we find that its proportion is largest with the lots giving the smallest increase: the same holds good with regard to loose fat so far as the Hampshires are concerned; and with the Sussex, though the lot of medium increase gives a higher proportion still, nevertheless the lot of smallest increase does give a higher amount of loose fat than the lot of largest increase. With this slight exception, then, the general fact, as stated above, seems fully borne out by the tenor of the results relating to it.

It is not our intention to enter further into questions of this

kind in this place; the weights of all the internal organs of the animals killed at home were however taken, but the results will be reserved for publication with many others of the same kind, when we take up the general question of the composition of the animals fed upon the farm, which we hope to do before long, in continuation of the subject already commenced in an article entitled "Sheep Feeding and Manure," in a former Number of this Journal.

We have found, then, in reference to the particulars of dead weights which have been given—

That the *proportion of carcass to live weight* differs very much among animals of equal rates of increase; that in both breeds, however, the lot of least increase gave the least average proportion of carcass; that there is a greater difference in regard to this point among the animals of the same breed than between breed and breed. Indeed, the results of carcass weight have brought out no distinctive points as between the two breeds, but rather show that its proportion depends more upon the quality and condition of the particular animal than upon the breed to which it belongs.

And with regard to loose or inside fat we also find great difference in its proportion, both among animals of equal increase and of the same breed; though, taking the average of the 16 in each case, but little difference between the two breeds. The Sussex sheep, however, gave slightly the higher proportion of loose fat.

Having traced the experiment thus far, we now come to the question of its money result.

The last weighing of the sheep was on May 8th, and, as we have already stated, it was decided to sell 16 dead at Newgate Market, 16 alive at Smithfield, and to feed the remaining 8 of each lot of 40 until Christmas.

The 16 of each lot for Smithfield were sent up to the following Monday's market, May 12th; and to the Newgate Market of the same day the 4 of largest and the 4 smallest increase of each breed were also sent, they having been killed in readiness on the Saturday. On Tuesday, 13th, the 8 of medium increase of each breed were killed in like manner, and sent up on the Wednesday night, for the Thursday morning's Newgate market.

In Tables XIII. and XIV., which follow, are given the proceeds of these sales, and the 8 to be fed on till Christmas are for the purposes of our calculation valued at the same amount per head as the 16 of each breed sold alive, to which their weights approximated very closely. The return for the wool and offal is also given. And in the right-hand division of the Tables is stated what would have been the produce of the 40, calculated at the rate of each of the separate sales.

TABLE XIII.—Produce of Sale of the Hampshires.

	Each Lot separately.				The Rates of each separate Lot, calculated as for 40 Sheep.		
	lbs.	£.	s.	d.	£.	s.	d.
8 Sheep—4 largest and 4 smallest increase } Carcasses, 2*s*. 9*d*. per stone	799	13	15	3	68	16	3
,, ,, Wool, at 13½*d*. per lb. . . .	49	2	15	1½	13	15	7½
,, ,, Skins, at 9*d*. each	..	0	6	0	1	10	0
,, ,, Heads and Plucks, at 1*s*. 2*d*. each	..	0	9	4	2	6	8
,, ,, Loose Fat, at 3*d*. per lb. . .	97	1	4	3	6	1	3
	..	18	9	11½	92	9	9½
Killing, 8*d*. per head; selling, and charges at Newgate Market, 7*s*. 4*d*.	..	0	12	8	3	3	4
Net for 8 Sheep sold dead .	..	17	17	3½	89	6	5½
Net per head	..	2	4	8			
8 medium Sheep—Carcasses, 3*s*. 3*d*. per stone . .	783	15	17	10	79	9	2
,, ,, Wool, at 13½*d*. per lb. . . .	46¾	2	12	7	13	2	11
,, ,, Skins, at 9*d*. each	..	0	6	0	1	10	0
,, ,, Heads and Plucks, at 1*s*. 2*d*. each	..	0	9	4	2	6	8
,, ,, Loose Fat, at 3½*d*. per lb. . .	99	1	8	10½	7	4	4½
	..	20	14	7½	103	13	1½
Killing, 8*d*. per head; selling, and charges at Newgate Market, 7*s*. 4*d*.	..	0	12	8	3	3	4
Net for 8 Sheep sold dead .	..	20	1	11½	100	9	9½
Net per head	..	2	10	3			
16 Sheep sold alive, at 41*s*. per head	..	32	16	0	82	0	0
,, ,, Wool, at 13½*d*. per lb. . . .	104	5	17	0	14	12	6
	..	38	13	0	96	12	6
Commission and selling . .	..	0	10	8	1	6	8
Net for 16 Sheep sold alive .	..	38	2	4	95	5	10
Net per head	..	2	7	7¾			
SUMMARY.							
4 Sheep of largest and 4 Sheep of smallest increase, sold dead	..	17	17	3½			
8 Sheep of medium increase, sold dead	..	20	1	11½			
16 Sheep of average increase, sold alive	..	38	2	4			
8 Sheep not sold, estimated at the price of the Sheep sold alive	..	19	1	2			
	..	95	2	9			
Average per head	..	2	7	6¾			

TABLE XIV.—Produce of Sale of the Sussex Sheep.

	Each Lot separately.				The Rates of each separate Lot, calculated as for 40 Sheep.		
	lbs.	£.	*s.*	*d.*	£.	*s.*	*d.*
8 Sheep—4 largest and 4 smallest increase } Carcasses, 3*s.* per stone	591	11	1	7	55	7	11
„ „ Wool, at 14*d.* per lb.	44½	2	11	11	12	19	7
„ „ Skins, at 7*d.* each	..	0	4	8	1	3	4
„ „ Heads and Plucks, at 1*s.* each	..	0	8	0	2	0	0
„ „ Loose Fat, at 3*d.* per lb.	74	0	18	6	4	12	6
	..	15	4	8	76	3	4
Killing, 8*d.* per head; selling, and charges at Newgate Market, 7*s.* 4*d.*	..	0	12	8	3	3	4
Net for 8 Sheep sold dead	..	14	12	0	73	0	0
Net per head	..	1	16	6			
8 medium Sheep—Carcasses, 3*s.* 4½*d.* per stone	610	12	17	4	64	6	8
„ „ Wool, at 14*d.* per lb.	45¼	2	12	9½	13	3	11½
„ „ Skins, at 7*d.* each	..	0	4	8	1	3	4
„ „ Heads and Plucks, at 1*s.* each	..	0	8	0	2	0	0
„ „ Loose Fat, at 3½*d.* per lb.	80	1	3	4	5	16	8
	..	17	6	1½	86	10	7½
Killing, 8*d.* per head; selling, and charges at Newgate Market, 7*s.* 4*d.*	..	0	12	8	3	3	4
Net for 8 Sheep sold dead	..	16	13	5½	83	7	3½
Net per head	..	2	1	8¼			
16 Sheep sold alive, at 35*s.* per head	..	28	0	0	70	0	0
„ „ Wool, at 14*d.* per lb.	90	5	5	0	13	2	6
	..	33	5	0	83	2	6
Commission and selling	..	0	10	8	1	6	8
Net for 16 Sheep sold alive	..	32	14	4	81	15	10
Net per head	..	2	0	11			
SUMMARY.							
4 Sheep of largest and 4 Sheep of smallest increase, sold dead	..	14	12	0			
8 Sheep of medium increase, sold dead	..	16	13	5½			
16 Sheep of average increase, sold alive	..	32	14	4			
8 Sheep not sold, estimated at the price of the Sheep sold alive	..	16	7	2			
	..	80	6	11½			
Average per head	..	2	0	2			

TABLE XV.—Summary—showing the Money Value of the *Forty Fat Sheep*, and the Average Value *per Head* (inclusive of Wool) at the rate of each Sale, and of the several Sales collectively.

	For the 40 Sheep.			Per Head.		
	£.	s.	d.	£.	s.	d.
HAMPSHIRES.						
At the rate of the four Sheep of largest and the four of smallest increase, sold dead	89	6	5½	2	4	8
At the rate of the eight Sheep of medium increase, sold dead	100	9	9½	2	10	3
At the rate of the sixteen average Sheep, sold alive . . .	95	5	10	2	7	7¾
Sixteen Sheep sold dead, sixteen alive, and eight estimated as sold alive, give	95	2	9	2	7	6¾
SUSSEX SHEEP.						
At the rate of the four Sheep of largest and the four of smallest increase, sold dead	73	0	0	1	16	6
At the rate of the eight Sheep of medium increase, sold dead	83	7	3½	2	1	8¼
At the rate of the sixteen average Sheep, sold alive . . .	81	15	10	2	0	11
Sixteen Sheep sold dead, sixteen alive, and eight estimated as sold alive, give	80	6	11½	2	0	2

It may be remarked by way of comment on Tables XIII. and XIV., which give the detail of the sales, that the carcasses were carefully weighed at home in the evening just before they were packed and sent off, this being 24 to 36 hours after the first weighings which were taken as soon as they left the hands of the butcher; but the weights allowed by the Newgate salesmen were less than our own by about 2½ lbs. per head. This, if correct, would be equivalent to a loss of weight one and a half times greater during the single night of the journey, and after the meat had become perfectly cold and stiff, than had taken place in 28 to 36 hours after the warm carcass had been first hung up in a spacious and airy barn. This loss we conceive to be quite impossible, but as the lots sold on May 12th and 15th respectively were sent to different salesmen, and the deficiency in weight was nearly equal with both of them, it would seem that *on some account or other the farmer loses about* 1*s. per head in this way.*

Again, referring to Tables XIII. and XIV., we see that the average price per stone of 8 lbs. of the first sale was for the Hampshires 2*s.* 9*d.*, and for the Sussex 3*s.*; and of the second sale, for the Hampshires 3*s.* 3*d.*, and for the Sussex 3*s.* 4½*d.* There is then a difference in favour of the Sussex mutton of 3*d.* per stone at the first sale, and of 1½*d.* per stone at the second. It will be remembered that the animals of the first sale were in each case the four of largest and the four of smallest increase; and that among the Hampshires therefore of this sale, we have the 3 "riggs" before referred to. These animals, which were

heavier than any of the others, sold at much lower rates than the rest; the average price of the Hampshires sold at the first sale is, therefore, rather unfairly reduced through this circumstance, and hence the greater difference in favour of the Sussex sheep at this sale. In the second sale, however, the Hampshires were all of them exceedingly nice mutton.

There is a difference of 6*d.* per stone between the first and second sale of Hampshires, and of 4½*d.* per stone between the first and second sale of Sussex sheep, which, it will be seen in Table XV., is equal to a difference of 5*s.* 7*d.* per head on the Hampshires and 5*s.* 2*d.* per head on the Sussex between the two days' sale. This serious difference was the result of a very flat market on May 13th, but as the disadvantage would be nearly equal for both breeds, the comparison between them is not thereby affected.

As nearly as can be estimated, deducting, of course, the value of the offal, the Hampshire sheep sold alive, also on May 13th, realized about 2*s.* 10½*d.* per stone, and the Sussex sold alive at the same time 3*s.* 2*d.* per stone.

At the foot of Tables XIII. and XIV. respectively are given the money value of each lot of 40 sheep, 32 of them being actually sold, and the remaining 8 of each calculated at the rate of the sheep sold alive; and a glance at the Summary, Table XV., will show that the price of the 40 as thus obtained, is, in the case of both the breeds, exceedingly near to the same rate that the animals sold for alive. In Tables XIII. and XIV. it is seen that the wool of the Sussex sheep fetched ½*d.* per lb. more than that of the Hampshires.

The loose fat (which includes both the caul and the gut fat) sold for ½*d.* per lb. more at the second sale than at the first, but this was the same for both breeds.

In attempting to make out a debtor and creditor account of a feeding experiment we meet with many difficulties, some of which we do not profess to overcome in the statement which we now subjoin. Indeed, we wish it to be clearly understood that in showing a balance account of the experiment we only seek to make a *fair comparison,* and by no means undertake to discuss in this place the question of the profit or loss of feeding generally, or of feeding in this particular case, considered as a branch of farming practice; but only to show as far as we are able what have been the *comparative merits* of the two breeds in a money point of view. With this limited object then, we charge against neither breed the cost of transit from the breeder, which would of course vary with the locality of the purchaser, nor do we make any charge for attendance or for the carriage of the animals to market at last.

With the still more serious items—the cost of the turnips consumed and the value of the manure produced, we must deal as best we can; but as the reader will have before him all the materials upon which the calculations are based, he will be able to arrive at his own conclusions, by any method he may think more applicable.

Excluding these items, then, for the present, we give in Tables XVI. and XVII. the cost of the lambs November 7th, when the experiment commenced, and that of the purchased food consumed —oil-cake and clover—on the one side; and, per contra, the produce of sale of the 40 fat sheep, as obtained in each case from 16 sold dead, 16 sold alive, and 8 calculated as sold alive.

TABLE XVI.—Balance Account of the Hampshires.

	£.	s.	d.	£	s.	d.
Cost of forty Hampshire Wether Lambs, November 7th, 1850, at 29*s.* per head	..			58	0	0
They consumed of purchased food:—						
8120 lbs. Oilcake, at 6*l.* 15*s.* per ton	24	9	4½			
7280 lbs. Clover Hay, at 4*l.* per ton	13	0	0			
Total purchased food	..			37	9	4½
				95	9	4½
Forty fat Hampshire Sheep, and Wool, sold May, 1851, for	..			95	2	9
Difference	..			0	6	7½

TABLE XVII.—Balance Account of the Sussex Sheep.

	£.	s.	d.	£.	s.	d.
Cost of forty Sussex Wether Lambs, November 7th, 1850, at 25*s.* 6*d.* per head	..			51	0	0
They consumed of purchased food:—						
6272 lbs. Oilcake, at 6*l.* 15*s.* per ton	18	18	0			
6020 lbs. Clover Hay, at 4*l.* per ton	10	15	0			
Total purchased food	..			29	13	0
				80	13	0
Forty fat Sussex Sheep, and Wool, sold May, 1851, for	..			80	6	11½
Difference	..			0	6	0½

The Hampshire lambs are here charged 29*s.* per head, and the Sussex 25*s.* 6*d.* The price paid for the Hampshires when bought in, was, however, 26*s.*, and that of the Sussex lambs 25*s.*; but three-pence per week per head is added to these prices for the time the animals were on *store keep*, before the experiment commenced, viz., 12 weeks for the Hampshires, and two for the

Sussex. The oilcake and the clover are charged at the prices paid for them delivered.

From these balance tables it appears, that in both cases the prices of the fat sheep (and their wool) covered, within a few shillings, the cost of the lambs and of the purchased food;—that is to say, the increase of animal has exactly paid for the purchased food. And it is remarkable that upon the whole 40 sheep in each case, there is a difference of only 7*d.* in this respect, between the two breeds, the Sussex having the advantage by this amount.

In both cases, then, the dry food has been paid for by the increased value of the 40 sheep, and in both cases, therefore, we have the manure of this food and of the turnips consumed, to pay for those turnips, and for attendance on the animals. Of course this exact equality between the value of the purchased food and that of the increase, is, to some extent, accidental; for the result would have been different had the whole 40 sheep been sold at the rate of either of the individual sales, instead of in several lots, as they actually were: indeed the rate of these sales may fairly be taken for illustrating this, as the average weight of animal being nearly the same at each sale, the difference in price was chiefly dependent upon the state of the market.

Thus, if all had been sold at the first sale, the increase of the Hampshires would not have paid for their dry food by 6*l.* 2*s.* 11*d.*, and that of the Sussex would have fallen short by 7*l.* 13*s.*; in favour of the Hampshires, therefore, in this respect, by 1*l.* 10*s.* 1*d.*

Again, if the second sale of dead meat had been our rule, the Hampshires would have given 5*l.* 0*s.* 4½*d.* more than the cost of their dry food, and the Sussex only 2*l.* 14*s.* 3½*d.*; in favour again of the Hampshires of 2*l.* 6*s.* 1*d.*

And lastly, if all had been sold at the rate of the 16 sold alive, the Hampshires would have been deficient by 3*s.* 6½*d.*, and the Sussex would have given a balance of 1*l.* 2*s.* 10*d.*; so that the rates of this sale would have been in favour of the Sussex sheep by 1*l.* 6*s.* 4½*d.*

These illustrations are only given to show how difficult it is to come to an unconditional decision as to money returns in such experiments; especially when the result is so nearly equal as in the two cases in question.

But even assuming that the artificial food has been in both cases exactly paid for by the increase of animal, leaving the manure of the dry food and of the turnips to pay for the attendance and for the turnips, this would not, of itself, be sufficient to prove equality of profit to the farmer, unless the quantity of turnips to be thus paid for were exactly the same, in both cases, in proportion to the dry foods consumed. It may be well, there-

fore, to trace the comparison a little further, if only as a means of pointing out the direction in which the true solution of such questions must be attained, involving, as it does, the value of the turnips and that of the manure, respecting which few farmers would agree; nor have they at present the necessary data at command, upon which to form any trustworthy judgment.

We find, then, that—

The Hampshires with 8120 lbs. of oilcake and 7280 lbs. of clover, consumed $49\frac{1}{3}$ tons of swedes; and that with 6272 lbs. of oilcake and 6020 lbs. of clover, the Sussex sheep have consumed $36\frac{1}{10}$ tons of Swedes.

The two lots of 40 sheep each, have therefore consumed very different quantities of turnips. But the farmer would of course adapt the number of his flock to his breadth of turnips, and therefore in keeping Sussex sheep would, according to their size, have a greater number of them than he would of Hampshires.

The question is, then, what would have been the quantity of the dry foods consumed, and the consequent relative value of the manure, supposing the number of the sheep had been such, in both cases, as to have consumed an equal quantity of turnips.

Suppose then that in both cases 100 tons of swedes had been eaten, we should have had consumed with them, and paid for by the increase of animal,—

	Oilcake. lbs.		Clover. lbs.
By the Sussex Sheep	17,374	and	16,676
By the Hampshires	16,470	„	14,767
Difference . . .	904	„	1,909

That is to say, in consuming 100 tons of swedes (and the dry foods), Sussex sheep would, according to our experiment, have given the manure from 904 lbs. more oilcake and 1909 lbs. more clover than the Hampshires. To have consumed the quantities of food supposed above, however, in 26 weeks, there would have been required 80 Hampshires and about 110 of the Sussex sheep.

According to this method of calculating the results, then, the Sussex sheep would have a slight advantage over the Hampshires as fatting stock kept upon the farm for their double produce of meat and manure; but so slight is the difference, and, as we have seen, so little would have thrown the balance in the opposite direction, that we do not consider that the experiment has shown any certain advantage in favour of either breed, but rather that the two as stock for rapid fattening on a liberal supply of artificial food, have very nearly equal merits in a money point of view.

It may perhaps be objected by the advocates of the respective breeds, that owing to the fluctuations which have been pointed

out in the apparent progress of the animals, the result would have been different had the experiment been concluded at some other period of its course than the one adopted. But although it is true that during single or individual periods of the experiment, the result as to the relative amount of increase given for an equal quantity of food would have been reversed, yet, if the experiment had been concluded at the end of twelve weeks, or at any of the succeeding periods of weighing, instead of in 26 weeks, the result would still have been the same in *direction*, though sometimes more and sometimes less in favour of the Hampshires than at present.

It is true, indeed, that from all the results given in the preceding pages, so various in their detail, yet giving in the gross some common points of consistency, we may at least learn over again the lesson that in seeking to elicit general rules, when the subtle principle of animal life is involved in our calculations, great caution is requisite so to multiply our results as to exclude the influence of casual and individual sources of error. Nevertheless we conceive that the gross results of 40 sheep fed for 26 weeks, cannot but be taken as giving some fair points of comparison, whether of a negative character or otherwise, as between the two breeds. And we believe that it may at least be concluded as the result of the experiment, that by the two, equal quantities of food will be consumed by a given weight of animal, within an equal period of time; but that the Hampshire will give a greater increase for this food than the Sussex sheep. In the case of our experiment this deficient weight of increase in the Sussex has been exactly compensated for by the greater quantity of the wool and the higher price of the Sussex mutton; and it is probable that wherever, as in the neighbourhood of London or other large towns, there is what may be termed a fancy price for Sussex mutton, that breed may, other things being equal, prove the most profitable, as it certainly is superior in form and general appearance. In many districts, however, no such fancy price exists, and in these localities —always supposing them otherwise fitted for either—the larger breed would probably be the most profitable. It is our intention to pursue this subject, however, and in our next experiment to include several other breeds of sheep, by which we hope to be able to decide more definitely as to the relation of food consumed to meat produced, by animals of different forms and weights.

The gross results of all the Tables embodied in the preceding pages, are given at one view in the following tabulated summary:

TABLE XVIII.

General Summary.

Particulars.			Actual Results of Experiments. Hampshire	Actual Results of Experiments. Sussex.	Per Centage Relation of Sussex to Hampshire. Relation of Sussex results to Hampshire as 100.	Per Centage Relation of Sussex to Hampshire. Difference.
			lbs. ozs.	lbs. ozs.		
Average weight per head when put up Nov. 7			113 7	88 0	77·57	−22·42
Average weight per head when fat (including wool)			183 1	141 0	77·02	−22·98
Total increase in weight of 40 sheep in 26 weeks			2,784 12	2,109 0	75·73	−24·27
Increase per head weekly			2 12	2 1¾	76·70	−23·29
Increase upon 100 lbs, live weight weekly			1 14	1 10¾	89·17	−10·83
Total food consumed by 40 sheep in 26 weeks . . . lbs.	Oilcake		8,120	6,272	77·24	−22·76
	Clover Hay		7,280	6,020	82·69	−17·31
	Swedes		110,467	80,897	73·23	−26·77
Food consumed per head weekly	Oilcake		8 0	6 3	77·34	−22·66
	Clover Hay		7 0	5 14	83·93	−16·07
	Swedes		106 10	79 1	74·15	−25·85
Food consumed per 100 lbs. live weight of animal weekly	Oilcake		5 6	5 6	100·00	None.
	Clover Hay		4 12¾	5 2	106·84	+ 6·84
	Swedes		71 7	68 14	96·41	− 3·59
Food consumed *to produce* 100 lbs. increase in live weight	Oilcake		294 0	314 4	106·89	+ 6·89
	Clover Hay		259 12	304 3	117·11	+17·11
	Swedes		3,941 0	4,086 0	103·68	+ 3·68
Total wool of 40 sheep, shorn March 27th			250 12	225 0	89·73	−10·27
Wool per head ditto ditto			6 4	5 10	90·00	−10·00
Wool, per 100 lbs. live weight of animal when shorn			3,775	4,567	120·98	+20·98
			st. lbs.	st. lbs.		
Average weights of cold carcass in stones of 8 lbs.	Of the 4 largest and 4 of smallest increase.	Weights taken at home	12 6½	9 4	74·15	−25·85
		Weights allowed by butcher	12 4	9 2	74·00	−26·00
	Of the 8 medium increase	Weights taken at home	12 4¾	9 5¾	77·17	−22·83
		Weights allowed by butcher	12 2	9 4¼	77·81	−22·19
	Of the 16 killed	Weights taken at home	12 5½	9 5½	75·24	−24·75
		Weights allowed by butcher	12 3	9 3	75·76	−24·24
Proportion of carcass (cold) in 100 of the live weight, of May 8th, *not fasted*	Of the 4 largest.		56·87	57·16	100·51	+ 0·51
	Of the 4 smallest		56·42	56·15	99·52	− 0·48
	Of the 8 medium		56·82	57·41	101·04	+ 1·045
	Of the 16 killed.		56·73	57·03	100·50	+ 0·53
Proportion of carcass (cold) in 100 lbs. of the fasted weight.	Of the 4 largest		61·24	61·81	100·93	+ 0·93
	Of the 4 smallest		60·00	59·28	98·80	− 1·20
	Of the 8 medium		60·64	60·57	99·88	− 0·12
	Of the 16 killed		60·63	60·56	99·88	− 0·12

PARTICULARS.		Actual Results of Experiments.		Per Centage Relation of Sussex to Hampshire.	
		Hampshire	Sussex.	Relation of Sussex results to Hampshire as 100.	Difference.
		lbs. ozs.	lbs. ozs.		
Average weight of loose fat per head (weighed warm)	Of the 4 largest	12 15½	10 4¼	70·22	−20·78
	Of the 4 smallest	11 5	8 6¾	74·43	−25·57
	Of the 8 medium	12 7	10 2½	81·56	−18·44
	Of the 16 killed	12 3¾	9 9¾	78·55	−21·45
Proportion of loose fat in 100 lbs. of the fasted weight	Of the 4 largest	6·54	7·08	108·26	+ 8·26
	Of the 4 smallest	7·34	7·17	97·64	− 2·36
	Of the 8 medium	7·24	7·45	102·94	+ 2·94
	Of the 16 killed.	7·02	7·10	101·18	+ 1·18
		lbs. ozs.	lbs. ozs.		
Average weight of lung and half windpipe per head (weighed warm)	Of the 4 largest	1 10¾	1 4½	76·77	−23·23
	Of the 4 smallest	1 9¼	1 3¾	77·86	−22·14
	Of the 8 medium	1 9½	1 6½	87·89	−12·11
	Of the 16 killed	1 9¾	1 5	81·00	−19·00
Proportion of lungs (including half the windpipe) in 100 lbs. of the fasted weight	Of the 4 largest	0·840	0·889	105·833	+5·833
	Of the 4 smallest	1·034	1·049	101·450	+1·450
	Of the 8 medium	0·933	1·031	110·504	+10·504
	Of the 16 killed	0·935	1·000	106·952	+6·952
		s. d.	*s d.*		
Price of the carcass per stone of 8 lbs.	At the 1st sale .	2 9	3 0	109·09	+ 9·09
	At the 2nd sale.	3 3	3 4½	103·85	+ 3·85
Gross money return per head of those sold dead (without wool)	Of the 8 sold May 12th	39 3¾	31 7¾	80·50	−19·50
	Of the 8 sold May 15th	45 4½	36 6¾	80·54	−19·46
Gross money return per head of the 16 of each sold alive (without wool)		41 0	35 0	85·37	−15·63
Average value of wool per head		7 0½	6 6½	92·90	— 7·10
Price of wool per lb..		1 1½	1 2	103·70	+ 3·70

XIX.—*On the Agricultural Geology of England and Wales.* By Joshua Trimmer.

Prize Report.

In writing on the Agricultural Geology of England and Wales, we must treat of it rather as it is not, and as it ought to be, than as it is.

This will be evident if we compare the objects proposed in the application of geology to agriculture with the means furnished

for their attainment by the present state of geological and agricultural knowledge respecting the composition and distribution of soils.

This essay will, therefore, treat of the objects of agricultural geology, and its present defective state, arising from the neglect of the superficial deposits. In tracing the rise and progress of the application of geology to agriculture, the probable cause of this defect will be indicated. The distribution of the superficial deposits or erratic tertiaries will be described; its dependence on the position and direction of the chains of hills; the peculiar characters of these deposits; their depth and composition; the heights to which they extend, and the districts most free from them. Such information respecting the distribution of soils as can be obtained from the Reports to the Board of Agriculture, and other agricultural works, will then be brought under view, in order to test the accuracy of the prevalent opinion that the variations of soil are dependent on the composition of the strata on which they rest.

In the course of these investigations we shall enter as little as possible into what some may regard as geological theories. It will, however, not always be possible, even if it were desirable, to describe geological facts, without some allusion to conclusions drawn from them respecting the agencies by which, and the periods at which, the phenomena described were produced. To those, moreover, who are unaccustomed to geological investigations, much will appear speculation which is in reality well established fact; such as the succession of the stratified rocks; the successive distinct assemblages of plants and animals contained in them; the aqueous origin of some rocks, the igneous origin of others; mountain chains formed at different epochs by disruption and upheaval of the strata along different lines; and repeated elevations and depressions of the same areas above and below the sea-level.

Objects of Agricultural Geology.—A knowledge of soils, subsoils, and substrata, constitutes the science of agricultural geology. Its objects are—1. The classification of soils on a sound and accurate basis, and the establishment of some general nomenclature of them for that Babel of local names which renders it nearly impossible for the cultivator of one district to know the nature of a soil on which a given process of cultivation has been found successful or unsuccessful in another.

2. Agricultural geology should be able to impart a knowledge of the laws of the distribution of soils; that is to say, where soils of a given quality, or adapted to a given system of husbandry, are to be found; whether each formation yields a peculiar soil which is co-extensive with the area allotted to it on

geological maps; and if not, then upon what conditions the variations depend.

3. The proper depths and distances of drains depend on the permeability of the soil and subsoil by water. A knowledge of this and of the phenomena of springs, which is essential to economy and efficiency in freeing land from water when it is redundant, and in obtaining a supply of it when deficient, constitutes one department of agricultural geology.

4. Another comprises a knowledge of the nature and properties and the distribution of mineral manures, or those substances which may be obtained from the subsoil and substrata for the correction of chemical and mechanical defects in the composition of the soil. It comprises also the establishment of a definite nomenclature for these, instead of that at present in use, which is as vague and unsatisfactory as the nomenclature of soils. When we are told of the benefits which have resulted from the application of marl or clay in a given district, who beyond the limits of the district can form any idea of the composition or geological relations of the substances to which the terms are applied, except that they are not farmyard manure, but that they are dug out of the earth, and that they are not caustic lime? Instances might be adduced in which the clay of one county, or one side of the same county, is the identical substance which is called marl in another.

5. Elevation above the sea, jointed structure and slaty cleavage, impregnation with metallic substances, and that metamorphic or altered condition which arises from contact with granite and other igneous masses, are local accidents to which the strata have been subject, and which must affect the character of soils derived wholly from rocks of the same formation. Soils, for instance, on the carboniferous limestone, which is spread out in broad undulations, at low levels, over so large a portion of Ireland, must have a very different value from soils on the same rock, at elevations of 1500 and 2000 feet, to say nothing of greater heights, in Yorkshire and Derbyshire. Soils also will be drier on rocks traversed by numerous joints and by slaty cleavage than on those which are destitute of them. Thin soils resting on such rocks, if the joints are numerous and the cleavage vertical or highly inclined, are great devourers of manure, which runs through them like a sieve. Salts injurious to vegetation prevail in soils resting on rocks which abound in metallic sulphurets. The mineral characters of the Devonian or old red sandstone rocks vary greatly in Herefordshire, Devonshire, and Russia, as they have or have not been subject to those local accidents which induce metamorphic structure. In Russia, where they have not been affected by contiguous masses of igneous rocks, or by lines of disturbance, but are spread

out in very nearly their original horizontal position, they appear under their original mineral aspect of clays and limestones, as soft and incoherent as our tertiary and newer secondary strata. In Devonshire they are so much indurated by contiguity to the granite of Dartmoor, as to assume the texture of the older slates and sandstones, with which they were till lately confounded. This altered condition is the form under which they most commonly occur on continental Europe; so that the old red was long supposed to be peculiar to the British Isles; and the first inquiry of a foreign geologist in England was for the *grès rouge antique.* In Herefordshire these rocks appear in a state intermediate between the condition of the same strata in Russia and in Devonshire. Soils derived from the two extremes of these conditions must differ as much as raw clay differs from ground bricks and tiles.

6. Agricultural geology should discriminate between soils composed exclusively of the materials of the rocks on which they rest, and those in which the materials have been derived from various strata and blended by aqueous transport.

7. The investigation of the sources whence materials for building, draining, and road making may be obtained, of the best quality, and at the cheapest rate, is a department of geology of no small importance to the farmer. It will often instruct him how, on the one hand, he may obtain, under or near to his own land, the very substances which he is bringing at a great expense from a distance; and, on the other hand, how, by means of railways, they may be brought twenty or thirty miles at a cheaper rate than from nearer sources of supply whence he is carting them with his own horses.

8. To these, which may be considered the direct influences of geological conditions on the agricultural capabilities of different districts, we may add the indirect influence, arising out of the distribution of those formations which affect the demand for the produce of the soil, by concentrating on certain areas large masses of population not employed in agriculture. A poor soil in the vicinity of Manchester, Leeds, Sheffield, Birmingham, and the other great manufacturing towns which are congregated on or near to the coal measures, will be of greater value than a better soil in a district thinly peopled and remote from markets.

Present imperfect state of Agricultural Geology.—Such are the questions which agricultural geology is required to answer. To some of the most important of them, which relate to the distribution of soils, it is unable, in its present state, to give more than very imperfect answers, because the greater part of the data necessary for their solution are yet uncollected.

For the purposes of agriculture, geological investigations should

embrace two classes of facts—the distribution and composition of the rock formations, and the distribution and composition of the drifts or erratic tertiaries. Geologists have occupied themselves too exclusively with the former; the latter, from their superficial position and the extensive areas which they cover, are of the most immediate importance in an agricultural point of view. There are but few large tracts in Britain which are wholly exempt from their influence. When they are only two feet thick they constitute in many cases both soil and subsoil. When their depth extends to seven feet, it is greater than that of the deepest drains of the deepest drainers. There are many places in which these deposits are several hundreds of feet thick, and then the substrata can have no agricultural value, except from the fossil manures which are furnished by their exposure within accessible distances. Even the fossil manures of the erratic deposits themselves are rarely raised from beneath a head or overburthen of more than twenty feet; twenty yards is the maximum we ever knew.

In our geological maps all these deposits are assumed as removed, and that rock is exhibited as constituting the surface, which would in that case be the surface. Nor is this the only defect of geological maps, as at present constructed, which detracts from their value for agricultural purposes. Agriculture requires a chemical, or, which is the same thing, a mineral classification of soils, while the classification of strata adopted in these maps is zoological. Their colours exhibit the areas occupied by the outcrop of certain groups of strata, made up of many subordinate beds, differing in mineral composition, but united by the bond of an assemblage of organic remains which is common to the whole group, and distinct from other fossil groups higher or lower in the series. For most purposes of geology such a classification is the best. A classification dependent on mineral characters had previously been tried, and found defective. We can ascertain by its organic contents to what part of the series a given rock belongs—by its mineral characters we cannot. The stratified rocks, whose collective thickness amounts to several miles, constitute a vast succession of strata, in which argillaceous, calcareous, and siliceous beds are repeated again and again. It is a general but not invariable truth, that the argillaceous, calcareous, and siliceous strata associated with the group of fossils which characterise one part of the series, differ somewhat from those associated with the peculiar organic remains of another. But while there are these differences vertically in different parts of the series, there are greater differences horizontally in different parts of the same formation. Its mineral characters are frequently changed in the distance of less than one hundred miles. Its zoological characters are the same at points thousands of

miles asunder. The lower oolitic group consists, in Gloucestershire, of calcareous rocks, known as the cornbrash, the forest marble, and the great, or Bath, oolite, associated with beds of clay—the fullers' earth bed and Bradford clay—and some sand. The inferior oolite, which forms the lowest bed of the group, and which is a ferruginous and calcareous rock, with occasionally much siliceous matter, passes in the north of Oxfordshire and in Northamptonshire and Rutland into a broad tract of ferruginous sands and sandstones. In Yorkshire it consists of sandstones and shales resembling those of the coal measures, and containing seams of inferior coal, the cornbrash being the only calcareous member which is constant, and the great oolite being represented by a thin calcareous band. The group is identified with that of Gloucestershire, under all these varying conditions, not only by containing the same group of fossils, but by having been followed continuously along the outcrop, so as to trace the gradual passage from one mineral form to another.

As another example, we may take the chalk. Through France, Belgium, Poland, and other parts of the north of Europe, it maintains its well-known English character of a soft and white carbonate of lime. In the south-east of Europe it assumes the form of soft clays and loose sands, not unlike parts of our plastic and London clay series. In America it is almost wholly arenaceous; but, under all these varying conditions, it contains the same group of shells, sponges, and fishes, and holds the same relative position to other assemblages of fossils which are found in England above or below the chalk.

It is of necessity, therefore, that our geological maps exhibit areas occupied by the outcrops of groups containing the same groups of fossils, no matter what their mineral character; but the mineral character of the strata, or of their several parts, is of the most importance to agriculture. If the superficial deposits were removed, as they are supposed to be, and if the soils were derived wholly from the rocks on which they rest, unaffected by aqueous transport and unmixed with other matter, it would be of more consequence to the agriculturist to know whether, in a given district, they consist of clay, sand, or limestone, than whether they contain certain fishes, reptiles, or mammals, and particular genera and species of shells. These mark the part of the series to which the strata belong, and they mark those minor modifications to which the argillaceous, calcareous, and siliceous strata are respectively subject in different parts of their vertical range; but these are of less importance than the broad argillaceous, calcareous, and siliceous characters belonging to them, which are independent of their place in the series.

Mineral characters are also of more practical importance than

the questions so interesting in theoretical geology, and on which the study of organic remains has thrown so much light respecting the ancient changes of the earth and its inhabitants. The information, therefore, which agriculture requires of geology is precisely that of which geological maps, as at present constructed, and the present prevalent course of geological inquiry furnish the least.

Rise and Progress of Agricultural Geology—probable Cause of this Defect.—During the half-century which has elapsed since geology has risen to the rank of a science of observation and induction, from being a mere mass of crude speculations, little progress has been made in its practical application to agriculture, chiefly because farmers have not been geologists, and geologists in general have been ignorant of agriculture. Whenever a step has been gained, it has been by the union of the two kinds of knowledge in one individual. The yeoman and land-surveyor of Oxfordshire who ranks as the father of English geology was also the first to apply it to agricultural questions.

Professor Sedgwick has observed of him, that he furnishes an instance of the manner in which things inconsiderable in themselves act on certain minds so as to influence the whole tenor of afterlife. Born in an oolitic district rich in fossils, which were the playthings of his childhood, he was led by them, while employed as a land-surveyor on the outcrop of the strata in central and southern England, to habits of observation, which terminated in his three great discoveries—that strata have an invariable order of succession; that each has been successively, and for a long time, the bed of the sea; and that each possesses a peculiar group of organic remains, by which, in the absence of other evidence, its place in the series may be determined. To the contemplation of his favourite oolites, on which he was born and lived, and on which he wished to be buried, we may trace a slight oolitic hue both in his geology and in its application to agriculture. The oolites of the south of England are more subdivided than elsewhere, and some of the subdivisions are characterised by peculiar species. It was natural, therefore, that his studies should receive a local impress, and that a local truth should be somewhat over-generalised by him. As observations multiplied and the science advanced, it was found that these minute distinctions could not be relied on, beyond certain limits, and that in the identification of strata we must look to broad features, to groups of fossils, as characterising groups of rocks. While the organic group, as a group, is constant under variations of mineral composition, mineral characters modify the distribution of its component parts, just as deposits now forming beneath the sea exhibit collectively the general assemblage of organic bodies now in

existence, subject to local modifications from climate, from the nature of the bottom, and from the depth of water—some animals inhabiting muddy, some sandy, some rocky bottoms, and some being peculiar to certain zones of depth. Smith's oolitic district, moreover, was one in which the influence of the rock formations on the soil is at or near its maximum; and it is not surprising that he should have assigned to them generally an influence which they really possess in some situations where the superficial deposits are absent, and should not have made sufficient allowance for the modifications produced, even under their slightest developement, by those deposits which are generally present to some extent or other.

Of Smith's views, however, on this subject we know but little directly. His great work was his Map of the Strata; and, though a most voluminous writer of notes, he published scarcely any books. Some who, availing themselves of the open liberality with which he communicated the results of his researches, called themselves his pupils, and some who, without even this acknowment, appropriated his discoveries, over-generalised his over-generalisations. Farey, the author of the Report to the Board of Agriculture on Derbyshire, carried this to the extreme of regarding shells as distinct species if they were found by him in more than one formation; thus involving himself, as Professor Sedgwick has remarked, in the vicious circle of first using organic remains for the identification of strata, and then using strata for the identification of organic remains. In like manner, Smith's views respecting the influence of the rock formations on soils, which are known only to those who have conversed with him or have heard him lecture, or who have access to his notes, may have become engrafted on agricultural geology in a somewhat exaggerated form, for he was one of the first to point out the difference between the stratified rocks and the superficial deposits; and the influence of the latter on the soil is too palpable in districts where they prevail to have escaped the notice of so accurate an observer.

From the time when Smith's active labours ceased little was done in the prosecution of agricultural geology, till the publication of Mr. Morton's work on Soils,* if we except the slight notices respecting the agricultural characters of the rock formations in the "Outlines of the Geology of England and Wales," by Conybeare and Phillips, and if we except also the Report on the Geology of Cornwall and Devon by Sir H. De la Beche. These two counties, but particularly the former, constitute a district in which the superficial deposits are of limited extent, and in which a more

* "The Nature and Property of Soils," &c., by John Morton. 1842. 3rd edition.

intimate connection than usual subsists between the soils and the rocks on which they rest. We find, accordingly, that Sir H. De la Beche takes the substratal view of the origin of soils, supposing them to have resulted from the decomposition of the subjacent rock *in situ*. He observes, however, of the chalk and greensand on the eastern borders of the district, that they are so overlaid by transported gravel as to possess a common agricultural character very different from that of the more eastern chalk districts, and by no means one of fertility. He mentions also other scattered deposits of gravel (besides the stream tin gravel of the valleys) in other parts of Devon and Cornwall. It is needless to enumerate more particularly the other points of that Report bearing on agriculture, because they have been republished by Sir H. De la Beche in the Journal of the Royal Agricultural Society, and have been more than once referred to by agricultural writers in that Journal. By far the greater part of the agricultural geology of England and Wales at present known is to be found in Mr. Morton's work on Soils, which has served as a text-book to most subsequent writers on the subject. It contains much valuable information respecting soils, the result of personal observation, and many useful hints for their improvement, but it falls into the prevailing error of drawing general conclusions from limited inductions, and assigning too much influence to the rock formations, and too little to the superficial deposits.

The points insisted on are, that the nature and colour of the soil partake of that of the subjacent rock, the principal mineral being that of the geological formation beneath—so that argillaceous soils rest on the clay formations, calcareous soils on the chalk, and oolites and siliceous soils on the various sandstones; the colour also of the soils being those of the rocks on which they repose—white on the chalk, red on the new red sandstone, and on the sands and clays in general nearly of the same colour as that of the stratum below. Any differences which exist are referred to the presence of animal or vegetable matter, or to exposure to the atmosphere and oxidation of the iron contained in the strata. This connection between the soil and the subjacent rock is insisted on as forming the best foundation for a classification of soils; many attempts, it is alleged, having been made to classify them on other principles, which have failed to convey to the mind either of the practical farmer or scientific agriculturist any correct idea of their nature and properties. Local names are therefore preferred by the author, and he proposes to classify soils by referring them to the geological formation on which they rest.

Diluvium is defined to be a vast accumulation of sand, gravel, and other materials which are found covering in masses some of the older and continuous geological formations to a greater or less

extent. A communication is also insisted on between the diluvial tracts and the rocks under or near them, though it is admitted that this is not always the case.

Three diluvial formations are described:—1. The diluvium resting on the chalk, referred to the wreck of the eocene tertiaries. This is described as consisting in some places of little else than flints; in some, as in Dorsetshire, of flinty gravel; in others, as in Kent, Surrey, Sussex, Hampshire, and Berkshire, of red tenacious clay, with rolled flints, varying in some instances to a loamy clay or to sand and gravel. 2. Diluvium of the new red, described as occurring in detached portions, often of considerable thickness, on that rock and on the coal measures, usually consisting of sand, but occasionally composed of clay. 3. The diluvium of the gault and Oxford clay, which may be traced through Lincolnshire and Northamptonshire into Wiltshire and Gloucestershire. Other minor diluvial accumulations are spoken of, consisting of local gravels, occupying limited and detached areas at the mouths of the deep valleys which intersect the oolitic hills, never as constituting deep deposits and assuming the form of hills like the diluvium of the new red. The sand and gravel, as well as the clay with fragmentary chalk, which cover the greater part of Norfolk and Suffolk, referred by other geologists to the diluvium, are regarded by Mr. Morton—we must add erroneously—as members of the plastic clay series. Of alluvial soils it is said, that as the materials of which they are composed depend entirely on the geological formation through which the rivers flow, of course the nature and property of the alluvium in each river or country may differ entirely from that of another.

Starting from these principles, Mr. Morton traces the changes of the different formations as laid down in geological maps, and describes in general outline the nature of the soils on each of the stratified and unstratified rocks. While certain general characters are ascribed to the soils on each formation, considerable local variations are admitted, which are assumed to be dependent on variations in the mineral composition of the rock beneath. Some of the specified variations, however, referred to this cause we know, from personal observation, to depend on the distribution of the superficial deposits.

The plastic clay of Essex, for instance, is described as yielding a reddish-brown clay on a clay subsoil, while in some places, as at Chelmsford, it yields a sandy loam, and a good turnip soil. "Indeed," it is added, "every variety of soil may be met with on this formation, which is owing to the rapid succession of sand and clay, and the other materials of which it consists." The cause of these variations will be noticed hereafter. To this formation

the soils of Hounslow Heath are also referred. They belong, however, to the superficial deposits, and exhibit every variety from deep and strong, to thin and gravelly, loams, having gravel at least fifteen feet deep interposed between them and the London clay, with which the gravel is in contact. Again, the soils of the plastic clay in Hampshire* are described as composed of flinty gravel, generally yellow, sometimes of a brown, red, or blackish colour; "from Ringwood, however, in the whole of its course eastward, it is a dark coloured gravelly or sandy loam on clay, mixed with reddish brick-earth and gravel, forming a very rich loam, similar to that of much of the London clay, where the sand is absent." From a minute examination of the eocene tertiary district west of the Southampton Water, we should describe it as overspread with erratic flint gravel, the sands and clays of the older tertiaries only appearing on the sides of steep escarpments and among broken ground. The poverty of the poor soils of Hampshire and Dorsetshire results partly from the coarse particles of which the siliceous sands when exposed are composed, but chiefly from the thinness of the covering of loam on the erratic gravel spread over the table lands. The good soils east of Ringwood, and along the whole southern coast nearly to Brighton, are caused by the deepening of the loam as the great valleys and the coast are approached.

Mr. Morton sums up the results of this examination of the soils on each formation in a section devoted to the classification of soils, in which they are divided into the aluminous, the calcareous, and the siliceous, to each of which divisions are referred the soils assigned to the different formations, in the following manner.

Aluminous Soils.

Clay the prevailing ingredient.

London clay Plastic clay Weald clay Clay of the coal measures	Little or no calcareous matter.
Blue lias Gault	A considerable portion of calcareous, with less siliceous matter than the last.

Calcareous Soils.

Lime in excess—much clay—little or no siliceous matter.

The lower chalk marl Some of the gault The clay of the oolite	Constituents impalpable.

* At the time Mr. Morton wrote, the eocene strata of Hampshire were referred to the plastic series. Mr. Prestwich has recently determined their true geological relations, which will be described in the sequel.

Diluvium of the Oxford clay . ,, ,, Lias	Calcareous gravelly soils.
The upper chalk . . . . Some of the lower chalk . . . The shelly oolite . . . . . . The great oolite	Soil composed of calcareous fragments, with little or no siliceous matter.
Magnesian limestone . . . . Carboniferous limestone . . .	Calcareous fragments, with a considerable portion of siliceous matter.

Siliceous Soils.

Silex the prevailing mineral, either as fine sand or gravel—clay the mineral next in abundance—lime sometimes present.

Sand of the plastic clay . . . Iron sand . . . . Millstone grit . . . . Old red sandstone . . . . . . Granite	Very friable, dry, and loose sand, with some aluminous, no calcareous matter.
Diluvium of the plastic clay . ,, ,, gault . . . . ,, ,, new red . . . ,, ,, coal measures.	Gravelly, strong soils, with a considerable portion of clay.
The graywacke, or clay slate . Some of the basalt	Soils composed of fragments.
The alluvial . . . . The greensand . . . . The new red sandstone . . . . The old red marls of Herefordshire . . . . Some of the basalt	Calcareous matter, silex, and clay—soils of the first quality.

This arrangement, it will be observed, is a deviation from the plan announced in the outset, of abjuring previous classifications and adhering to local names, referring them to the geological formations on which they rest. It is, to all intents and purposes, a chemical classification of soils, and a reference of those of each formation to one or other of the chemical divisions: and some such double classification soils require—chemical as regards their composition, geological as regards their relation to the different rock formations, to the erratic tertiaries (diluvium) or the alluvial deposits.

The characters assigned to the soils may be considered as the prevailing characters of the formation *when the rocks are exempt from the influence of the surface deposits.* They can only be received under this limitation. The extent of each formation so circumstanced is a question into which the author has scarcely entered. There are variations moreover in the mineral character of many of the rock formations, which are passed over with little notice, and which, supposing soils to be wholly derived from the

rock on which they rest, would produce considerable variations from the standard assigned to the soils of each formation.

On the other hand, variations in the strata, which have no existence, are assumed in explanation of variations of soil, which are dependent on the superficial deposits. The doctrine, moreover, that the alluvium of each river or district varies with the geological formations through which the rivers flow, can only be admitted as true of deposits of rivers flowing entirely through one or two formations, which are very rare instances except in the case of the minor tributaries. A glance at a geological map is sufficient to show that the Thames, the Severn, and the rivers which flow into the estuaries of the Wash and the Humber, unwater catchment basins, composed of many formations, and covered by erratic tertiaries of considerable thickness which contain a great variety of fragmentary matter derived from different quarters. The fine detritus of such rivers which reaches their mouths and enters into the composition of the soils of our principal alluvial districts must therefore be of a very mixed character. Professor Phillips has shown, moreover, that the warp deposited by the Humber is derived more from the wasting cliffs of Holderness, brought up with the tide, than from detritus brought down from the interior by the rivers; and recent microscopic researches have established the fact that a large proportion is not detritus of any kind, but made up of the siliceous covering of minute animalcules.

It is, however, needless to insist on these points, as we have reason to believe that Mr. Morton's views have undergone considerable modification, and that he now finds "warp of the drift," and "basins of drift," in many situations where he would formerly have considered the soil to be derived exclusively from the subjacent rock. His work has the merit of having once more drawn attention to the subject of agricultural geology, which had long been dormant, and of being a good first approximation to results which require for their completion much more extended observation than they have yet received. An examination of the soils of England and Wales for the purpose of determining their variations and their relation to the rock formations of our geological maps, or to the erratic tertiaries which are excluded from them, would require the constant work of ten surveyors for thirty years.

Professor Johnston, in his Lectures on Agricultural Chemistry and Geology, has acknowledged his obligations to Mr. Morton for the description of the agricultural characters of the strata of the south of England. Residing, however, in the north, in a district thickly covered with erratic tertiaries or drift, he has been more impressed with their influence on the distribution of soils,

and has pointed out the geology of the surface as of more immediate importance to agriculture than that of the rock formations. He has declared that Agriculture now requires "maps of her own,"—maps which shall exhibit the extent and composition of the superficial deposits; and that notwithstanding the useful labours of the Government Geological Survey, the construction of maps of the superficial deposits, which should show the agricultural capabilities of different districts, based on a knowledge of their soils and subsoils, and the sources from which they have been derived, whether near at hand or remote, is a work well worthy the patronage of our leading Agricultural Associations.

Course of investigation required.—The true inductive method by which to determine the relative influence of the rocks and the superficial deposits on the character of the soil, requires that the variations of the latter should be laid down on the scale of our best geological maps, and that the information should be noted which is furnished by every available section respecting the mineral character of that which, though the real substratum, is the assumed surface of those maps. The depth and composition of the various beds belonging to the superficial deposits between such stratum and the soil, should also be indicated. We are not aware that more than two attempts have been made in England to collect this information. The first was a map of the soils of a large portion of Norfolk, undertaken as the basis of a paper on the geology of that county, as illustrative of the laws of the distribution of soils, which was published in the Seventh Volume of the Journal of the Royal Agricultural Society. The other was a map of part of South Wales, constructed on the same plan, for the Government Geological Survey. In both these cases the variations of soil were found to be mainly dependent on other conditions than the composition of the subjacent rock. The author of those maps has acknowledged that the idea of constructing the first of them was suggested by the passage above referred to in the Lectures of Professor Johnston; who has himself produced two maps, the one agricultural, the other geological, appended to a "Report on the Agricultural Capabilities of New Brunswick," which was made during his recent visit to America, and published by the Colonial Legislature.

The only means at present existing for submitting the whole of England and Wales to the test proposed, is by collecting such information as geology furnishes respecting the distribution of the superficial deposits, together with such still less perfect information as can be obtained from the Reports to the Board of Agriculture and other Agricultural writings respecting the distribution of soils, comparing the results thus obtained with our best geological maps.

The results of such an examination have convinced us, that the views announced in the paper on the Geology of Norfolk, before alluded to, are not merely local truths, but that, in most cases, the variations in the soil are more dependent on the operations which caused the accumulation of the erratic tertiaries during a period of gradual submergence, and their denudation during a period of re-elevation at the close of the tertiary period, than to the rock formations; the soil itself being, in most cases, an aqueous deposit, thrown down unconformably on the denuded surface of the erratic tertiaries, or of the older strata when the denuding action has reached them. We do not enter here into the question when this unconformable deposit was formed—nor of the nature of the agencies by which it was formed—whether it was the effect of the last wash of the sea on the emerging land, or whether, as there is good reason to believe, it was the result of subsequent operations after the desiccated bed of the sea had existed a considerable time as dry land. These are questions of greater theoretical than practical interest. The existence of such a deposit is the important agricultural fact. The dependence of the variations of soils on contours, and the indications these afford respecting the situations in which the best, that is, the deepest, driest, and most mixed soils are to be found, will be nearly the same, whether an interval elapsed between the emergence of the land from beneath the erratic sea and the formation of this deposit, or whether the two events were contemporaneous.

Influence of physical features on the distribution of the erratic tertiaries.—The distribution of the erratic tertiaries has been influenced by the general configuration of the great features of the land, which were established before the submergence under which the erratic deposit accumulated; that is to say, by the position and direction of the mountain chains and ranges of hills. These were the results of disturbing forces, by which the strata have been fractured and tilted up along different lines at different periods.

The mountains and hills of England may be thus enumerated. In the extreme north we have the porphyritic ridge of the Cheviots. A little further to the south-west are the mountains of the English lake district, or Cumbrian chain; and, still further to the south, those of Wales; both consisting of silurian and older rocks, of various mineral character, associated with igneous rocks as various in their composition. Down the centre of England extends the great Penine chain,* which ranges from the Tyne to the Trent, and is composed of carboniferous limestone, millstone-

* The ALPES PENINI of Roman Britain.—See Conybeare's 'Outlines,' p. 365.

grit, and coal measures. Near it, on the south-east, are the syenitic outbursts of Charnwood Forest. Further to the south-west are the silurian rocks and associated traps and syenites of the Malverns. The chalk and oolites have been thrown up in parallel ridges, with a strike curving first to the south-east and then to the south-west, and ranging from Flamborough Head in Yorkshire to the coast of Devon and Dorset. The oolitic ridges are known in Yorkshire as the Hambledon and Howardian Hills (middle oolite), and the eastern Moors (lower oolite). The prolongation of the ridge of the lower oolite to the south-west forms the Cotswolds of Oxfordshire and Gloucestershire. The chalk range is known as the Wolds of Yorkshire and Lincolnshire, the Downs of Norfolk, the Gogmagog Hills of Cambridge, the Dunstable, Luton, and Warden White Hills of Bedfordshire, the Chilterns of Buckinghamshire, Berkshire, and Oxfordshire, passing into the elevated platform of Salisbury Plain and the Hampshire Hills, and terminating on the coast of Dorsetshire in the steep ridge of Purbeck Hill. The elevation of the chalk from north-east to south-west appears to have been prior to the deposit of the eocene tertiaries and London clay, which are only found on the east of it; but another, and subsequent line of disturbance, ranging east and west, has thrown up the chalk ranges of the North and South Downs, exposing the subjacent oolitic strata of the Wealden, in the triangular denudation between them, and separating the once continuous eocene tertiaries into the districts commonly, though erroneously, called basins, of London and Hampshire.

The position and direction of the chains of hills have influenced the lines of the rivers; they have also influenced the distribution of the erratic tertiaries. These, however, are quite independent of the rivers. They are far above the influence of existing streams, which, so far from having formed them, have in many cases cut deep channels through them.

Marine origin of the erratic deposits on submerged land.—The marine origin of the erratic deposits is proved by the marine shells locally distributed through them at many points and over wide areas. From the large percentage of shells of existing species which these deposits contain, they are proved to belong to that portion of the tertiary series which, in the classification of Lyell, is called the pleistocene, or newer pliocene. The same fact is proved by their superposition in Norfolk to the mammalian crag, or older pliocene. England is proved to have been dry land, inhabited by the elephant, rhinoceros, hippopotamus, and other large mammals, before its submergence beneath the sea of this epoch; by the forest at Cromer and Happisburgh, buried beneath more than three hundred feet of these erratic tertiaries, and

rooted on the fluvio-marine deposit containing the mammalian remains. The same fact is also attested by the presence of the remains of the rhinoceros and hyæna in Cefn Cave, in Denbighshire, beneath sand containing the marine remains of the erratic tertiaries which overspread the surrounding country.

Peculiar characters of the erratic tertiaries.—There are peculiarities in the composition of these marine deposits which distinguish them from other tertiary strata, and which, combined with their present irregularity of distribution—an irregularity rather apparent than real, and the result of denuding action—caused them at one time to be referred to the transient action of the sea bursting in enormous waves over the land. The characters which were deemed proofs of such transient action are the slightly worn and scratched condition of the smaller detritus and larger blocks; the rounded, polished, and striated condition in some places of the rocks on which they rest—in others their shattered state; the masses of fragmentary matter enveloped in these deposits, which must have been transported from various distances, unabraded and unmixed with other matter; the large size of some of the far transported blocks or boulders; the great irregularities of surface over which they must have travelled; their transport from lower to higher levels; the broken condition of the shells; their general absence from large areas and from a great depth of deposits; the confused intermixture of species indicating different habits, and different zones of depth; their arctic character; the arctic character of the associated mammals, not even excepting the elephant and rhinoceros, which are proved by the woolly covering of those carcases which have been preserved with the flesh and integuments entire in the frozen cliffs of Siberia, to have been capable of enduring the rigours of a northern climate. These, and other phenomena, too numerous to be specified, which are in perfect accordance with the atmospheric and marine action of an arctic climate, as described by the polar navigators, combine to render gradual submergence of the land, proceeding from north to south, while an arctic climate was advancing southwards, and its gradual re-elevation to about its former level, during the return of a milder climate, the most probable solution of the complicated phenomena of the erratic tertiaries.

We prefer the term erratic tertiaries to that of pleistocene, in order to distinguish them from those probably contemporaneous deposits of more southern regions which are destitute of the erratic characters above described; and though we believe those characters to have resulted from the action of shore ice, and floating icebergs, and of an arctic climate on sinking land, we prefer the term erratic to that of glacial, as involving no theoretical consideration, but merely expressing the fact of the presence of

those large boulders, transported at this epoch, over a great part of the north of Europe and America, and over that small portion of the southern hemisphere, in corresponding latitudes, which is now dry land.

In tracing the erratic tertiaries of England and Wales it is found that a large portion of the detritus of which they are composed has been derived from the neighbouring rocks; and that it has been mixed with much other matter transported several hundreds of miles from the N.N.W. and N.E.

Dispersion of Cumbrian Erratics.—Of the many districts which furnish rocks of peculiar characters, whose fragments in the erratic tertiaries indicate the direction of the transporting currents, there are few more remarkable than the lake district of the north of England—few which furnish rocks of such peculiar mineral characters, and limited to areas so small and well-defined, as to preclude all mistake in the identification of their scattered blocks and smaller detritus, and in tracing the lines along which they have been transported. These peculiar rocks are the granite of Shapfell, the syenitic greenstone of Carrockfell, and the calcareous conglomerate of Kirby Stephen. Not only have blocks of these rocks, often weighing many tons, been transported northwards, eastwards, and southwards—chiefly in the latter direction, along the depression between the mountain chains—but they have been borne over great irregularities of surface, eastward across the ridge of Orton and the Vale of Eden—a pre-existing valley containing deposits of the new red unconformable to the disturbed rocks which bound it. This valley crossed, the Penine chain has opposed a higher barrier to their progress eastward, which they have surmounted at one point—the pass of Stainmoor—the lowest pass in that chain opening directly to the west, and 1400 feet above the level of the sea. From this point, as from a new centre, they have radiated down the eastern slope of the chain, traversing the vale of Tees to Redcar, and the vale of York to the Humber.

The oolitic and chalk ridges of the eastern moorlands and the Wolds have opposed obstacles to their passage, similar to those presented by the Penine chain, though on a smaller scale. These have been surmounted, in like manner, at their lowest points, so that blocks of Shapfell granite lie on the oolite near Scarborough, and on the chalk near Flamborough Head.

The Cumbrian erratic blocks have likewise travelled eastward to the mouth of the Tyne, along the depression caused by the Tynedale-fault, at the northern termination of the Penine chain, though the streams flowing in that direction are quite unconnected with the mountains from which the blocks have been derived. They have likewise gone northward along the Vale of

Eden to Carlisle, where they are mixed with erratic blocks which have crossed the Solway Frith. They have been drifted southwards in immense quantities by Lancaster and the narrow tract between the mountains and the sea, crossing the lines of the Lune, Ribble, Wyre, Weaver, Mersey, and Dee; and spreading over the plain of the new red sandstone in Cheshire and Shropshire, into the valleys of the Severn and the Trent. Throughout this large area they are mixed with other granitic fragments, of various sizes, which may be referred to the Isle of Man and the Mourne mountains in Ireland, and which are partly on the surface, partly imbedded in deep strata of sand, gravel, and clay. Large erratic blocks of northern origin are lodged, in great numbers and at great heights, on the northern flanks of the Welch mountains. Granite blocks are also found on the N.W. skirts of the chain, as far as Bagillt; but from that point they diminish in size, and S. of Conwy the Cumbrian and Scottish granites give place to smaller granitic fragments, most of which appear to have come from Wicklow and other parts of Ireland.* They are associated with fragments of other rocks which indicate transport from the N.W. Among the most remarkable of these is the hard chalk of the county of Antrim, of which a continuous stream has been traced, in Ireland, from its source as far S. as Wexford.

The tail of this stream of Antrim detritus appears to have caught the Welch coast, for we have found it in the boulder clay of the extreme point of Caernarvonshire, and much further to the south, between Newport and St. David's Head in South Wales.

Erratics of the East of England.—The erratic blocks from the lake district of Westmoreland, which were traced across the Penine chain to the sea coast of Yorkshire, have there met another stream of granitic and other crystalline blocks, which must have been derived from the east of Scotland and from Norway, these being the nearest points at which such rocks exist *in place*. This forms the commencement of that district of erratic tertiaries, described in the seventh volume of the Journal of the Royal Agricultural Society, as extending, with some alluvial interruptions, to the valley of the Thames. In the valley of the Waveney erratic blocks and bouldered oolitic fossils abound, and, from their increasing prevalence westward, there can be no doubt that they were derived from that quarter. Boulder clay, with granitic, oolitic, and other foreign detritus of various kinds, extends from Norfolk through Cambridgeshire, Suffolk, and Essex, to the northern side of Hampstead Hill, where

* Journ. Geol. Soc. Dublin, vol. i. part iii. p. 180.

pebbles of crystalline and subcrystalline rocks have been found, mixed with a great abundance of erratic fossils of the oolites.

Erratic Gravel of the Midland Counties.—Returning now to the tract bounded on the W. by the Welch mountains and the Malverns, and on the E. by the Penine chain and the Cotswold Hills, we find that granitic boulders extend as far southwards as Bridgenorth, from which point they decrease in size and quantity, till they pass off into coarse gravel, composed of the same materials, which dies off in the fine gravel and sand of the vale of Gloucester. Marine shells have been found in this gravel at various points, the most southern of which is about three miles south of Worcester.

Before the granitic fragments disappear, other detritus of marked character comes in, by which we are enabled to trace the direction of the drifted materials of the erratic deposit further to the south.* The most remarkable of these are the pebbles of the lower Lickey quartz rock. Fragments of this rock reduced to the state of rolled pebbles by the marine action of the new red sandstone epoch had been consolidated into a conglomerate of that series, which forms the upper Lickey range. This conglomerate having been subsequently broken up by the operations of the erratic period, its rounded pebbles, mixed with the angular and partially worn fragments of the local rocks, form a gravel, which is spread, in enormous quantities, over the midland counties, particularly about Cannock Chase, in Staffordshire, and Coleshill, E. of Birmingham. It has been collected also in large masses along the plains subjacent to the great oolite escarpment, N.E. of Shipston-on-Stour, in Warwickshire. The other fragments with which the pebbles of the Lickey quartz rock are associated consist of white quartz, flinty slate, gneiss, porphyry, compact felspar, trap, sandstone of several kinds, lias, chalk, and flint. The gneiss must have come from Scotland or Norway, the white quartz and the slaty and porphyritic pebbles may have been derived either from the mountains of Wales or from Charnwood Forest.

In short, in the centre of England, W. of the oolitic escarpment, we have the junction of a line of drift from the N.W. with another from the N.E. The united drift having crossed the Cotswolds through a gap or depression in the ridge, takes a S.E. direction into the valley of the Thames as far as London.

The most distinctive detritus of the midland counties, having a north-eastern origin, consists of pebbles † of the red chalk of Yorkshire, Lincolnshire, and the N.W. angle of Norfolk at Hunstanton, which does not occur in place further S. Frag-

* Buckland, Geol. Trans., First Series, vol. v. p. 521. † Ibid.

ments of this peculiar rock are found, according to Dr. Buckland, mixed with the Warwickshire gravel, S.E. of Shipston-on-Stour, and near Moreton in the Marsh, associated with pebbles of the hard white chalk, which accompanies the red chalk in Yorkshire and Lincolnshire.

It has been already stated that this gravel of the midland counties has crossed the oolitic ridge. The passage, like that of the Cumbrian erratics, has been effected at the lowest points. One of these is near Moreton in the Marsh. Deflected thence eastward, by the elevated ridge of Stow on the Wold, the gravel has proceeded along the line of the Evenlode, where it joins that of the Thames, four miles north-west of Oxford. Great accumulations of gravel, containing pebbles of the Lickey quartz rock, not only cover irregularly the lower regions of the valley of the Evenlode, but are scattered abundantly over the oolitic strata, which form tablelands of considerable height on both sides of it. Accumulations of similar gravel rest on the insulated and almost conical summit of Wytham-hill and the ridge of Bagley-wood, exactly opposite the confluence of the Evenlode with the Thames. In like manner the quartzose gravel of Warwickshire has entered the valley of the Cherwell, through another gap in the oolitic escarpment, and has passed onwards, mixed with chalk flints, and slightly-rolled oolitic detritus, into the valley of the Thames. Along the valley of the Thames the quartzose pebbles, in continually decreasing quantities, and mixed with the gravelly wreck of each succeeding formation, have been traced to the gravel-pits of Kensington and Hyde-park. They also accompany granitic pebbles, in the flint gravel at Brentford, below the deposits containing bones of elephants and other large mammals, with freshwater shells.

The absence of the Warwickshire gravel from the valley of the Windrush, separated from that of the Evenlode by the narrow ridge of Stow on the Wold, and the local character of its gravel, caused by the Windrush taking its rise within the elevated range of the Cotswolds, and by there being no depression, or breach of continuity, like those at the heads of the Evenlode and Cherwell, through which the Warwickshire gravel entered their valleys, prove the establishment of the present general features, near the head-waters of the Thames, before the formation of those erratic deposits, and the influence of those features in determining the distribution of the gravel; but on the other hand,* Dr. Buckland, who described these deposits in 1817, inferred—from the accumulation of it upon Wytham-hill, Bagley-wood, Henley and Cumnor hills, and on the highest summit of Wychwood-forest, as

* Geol. Trans., First Series, vol. v. p. 521.

well as on the elevated table-lands which flank the course of the Evenlode above Oxford—that the excavation of the valleys of the Evenlode and Thames was subsequent to the deposit of this gravel, and caused by the retiring waters of the most recent deluge that has devastated the earth.

This argument for the recent origin of the valley of the Thames is of equal force now, when we possess better information respecting the nature of these deposits, if for the expression, retiring diluvian waters, we substitute that of denuding process during elevation.

The occurrence of pebbles of the red chalk, in the quartzose gravel near Shipston on Stour, and Moreton in the Marsh, has been mentioned as indicating the meeting of a stream of drift from the north-west with another from the north-east. The northern part of the course of the latter was described by the Dean of Llandaff,* in a communication to Dr. Buckland, under the title of gravel of the midland counties in Rutland, Leicester, and Buckinghamshire. It extends, he says, over the plains at the base of the great oolitic chain, and also between those hills and the south-west escarpment of the chalk in Bedfordshire, Buckinghamshire, and Hertfordshire, but is most abundant in the former position, having a depth of many fathoms, completely concealing the subjacent strata, and sometimes constituting decided hills. Such tracts of gravel are described as abundant on the borders of Rutland, Warwickshire, and Leicestershire. From Houghton on the Hill, near Leicester, by Market Harborough and Lutterworth, to Bramston, near Daventry, continuous beds of gravel extend for forty miles. Near Hinckley a great deposit of gravel, connected with this mass, affords pebbles containing specimens of the organic remains of most of the secondary strata of Britain. It may be traced continuously to that of Shipston on Stour. Most of the hillocks scattered over the lias and red marl between Southam and Shipston are covered with this gravel, containing pebbles of all ages; flints from the chalk, rounded pebbles of hard chalk, and fragments of the different oolitic rocks predominate in Leicestershire: next in abundance to these are the pebbles of granular quartz, resembling that of the Lickey, with others of white quartz, and dark-coloured flinty slate.

On the west of Market Harborough it would not be difficult to form an almost complete collection of geological specimens of the whole series of English rocks from among these rounded fragments, which often occur in boulders of very considerable size.

The gravel-beds in the low grounds between the oolitic and chalk ridges, and along the valley of Buckingham and Bedford, and

* In the volume of the Geol. Trans. cited above.

skirting the lower or south-eastern slope of the great oolitic range, are almost exclusively composed of fragments of oolite and chalk, older pebbles being very sparingly intermixed. Examples occur in Whittlebury-forest, Northamptonshire, and near Buckingham. The flint gravel used for the repair of the road about Dunstable, near the escarpment of the chalk, and which contains porphyry, was identified by Dr. Buckland with that traced from Warwickshire, along the valleys of the Thames, Cherwell, and Evenlode, to London, and with that of the north midland counties described by the Dean of Llandaff.

From Farey's 'Report on Derbyshire,' it appears that fragments of all formations, from granite to chalk, have accumulated on the surface of all the strata which constitute the centre of England.

Review of the General Distribution of the Erratic Deposits north of the Thames—Division into Upper and Lower Erratics.—From the Scottish border to the Thames we have thus evidence of marine action of very recent date over the whole of that part of England and Wales, producing a great intermixture of local and far-transported matter, in the form of gravel, clay, sand, and boulders; and we may be sure that the agencies which transported the coarser materials transported also much fine extraneous matter, which has been mixed with that derived from the neighbouring rocks to form the soil.

The strike of the strata, which has given their direction to the ridges of elevated land, influenced the distribution of the transported detritus. We have three lines of drift from the north-east: that on the east of the chalk ridge, extending from Holderness to Hampstead; that between the chalk and the great oolite; and that west of the oolitic ridge. We have four from the west: that of the Cumbrian erratics which have crossed the Penine chain to the German Ocean; that of the Irish detritus lodged on the western flanks of the Welch mountains, and that of the Lickey quartz rock drifted eastward towards the oolitic ridge, and across the Cotswolds, into the vale of London. We have also, in several cases, indications, with a general drift towards the south, of a slight drifting northwards. These facts, including the last, are quite in accordance with the motions of shore-ice, as described in the polar voyages, influenced more by winds than by tides, and sometimes moving, under this influence, in opposition to the general current from the north. Such a general northern current would also be subject to many local modifications, from the ridges of hills and mountains which would become groups of islands and promontories, or submarine ridges, as the land subsided.

Every science furnishes instances during the early stages of its

progress of erroneous conclusions from imperfect data which have been corrected by advancing knowledge, derived from more extended observation. Geology has not been more exempt from these than the exact sciences of astronomy and chemistry. By one of those hasty generalisations, all the detrital deposits above described, together with all gravel beds in all parts of the world, including many tertiary strata of much older date, were once on insufficient evidence assumed to be contemporaneous and monuments of the Noachian deluge. It has since been assumed, on evidence equally insufficient, that they belong to different epochs. We view them as the results of a connected series of operations, during one zoological epoch—an epoch of considerable duration—the series of operations being the accumulation of the deposits during the subsidence, and their denudation during re-elevation of the land. If space permitted, it would be easy to show how the distribution of these deposits, the intermixture of foreign and local detritus in some situations, the prevalence of local gravel in others, and the absence of all detritus from some localities, agree with the theory of the action of shore-ice on sinking land, the gradual advance of the coast-line into the interior during subsidence, and the transport of local fragments outwards during the period of elevation; but our object is the application of the surface-geology of England and Wales to its agriculture, and we would rather draw attention to the large area which has been covered with these deposits, the materials of which they are composed, and the height to which they have ascended.

In the first place, then, it is a general fact, common to the area now under consideration, and to every district which we have examined in Ireland, that the erratic tertiaries consist of a lower and an upper deposit, the former composed of clay, the latter of sand and gravel. The colour of the lower deposit, the till or boulder clay, is blue, brown, red, yellow, or white from intermixture of chalk, with various intermediate shades, according to the prevalent colour of the rocks from which it has been derived, which are chiefly those of the neighbourhood. The peculiarities of this lower bed indicate the littoral action of an icy sea, in which it appears, from the observations and soundings of the polar navigators, that mud accumulates in situations where sand and shingle would be deposited in other seas.

The sand and gravel of the upper erratics partake more of the characters of ordinary tertiary strata; but they possess some peculiarities, such as the occasional presence of masses of fragmentary matter unabraded and unmixed with other detritus, and the presence also of blocks of large size, derived from far distant rocks. Both of these appear to require some buoyant material for their transport. The difference between the lower and upper

erratics may be attributed to the decrease, during the formation of the latter, of neighbouring land as submergence proceeded, and in part to the mitigated rigour of the climate.

Both deposits contain marine shells, more abundantly in some districts than in others. In both the shells are much broken, and there is an intermixture of species of different habits. In both regular beds of them are extremely rare. All beds of this kind which we have ourselves examined appear referable either to the period which immediately preceded the commencement of the erratic phenomena, or to that which characterised its close, and the passage into the alluvial period. With respect to the height to which these deposits ascend, all that can be determined, in districts like Norfolk, whose elevation is less than 600 feet, is, that their highest tracts were submerged. Regions of greater elevation, like the Cambrian, Cumbrian, and Penine chains, afforded evidence of submergence to a much greater depth.

"It is marvellous," says Mr. Darwin, "that Nature should have marked, by buoys made of stone, the former sinking of the earth's crust, and likewise, I may add, its subsequent elevation; and that on these blocks of stone the temperature during the long period of their transportal may be said to be plainly engraved."*

On the Penine chain erratic blocks are found, as we have stated, at the height of 1400 feet; and there is reason to believe that the Cumbrian chain was submerged to about the same depth.

On Moel Tryfan, in Caernarvonshire, shells and granitic detritus, with chalk flints, have been found at somewhat less than 1392 feet. Blocks of granite are lodged at heights of about 1000 feet on the northern flanks of the Welch mountains. Shells and blocks and pebbles of granite are spread over the new red sandstone and coal-measures of Lancashire and Cheshire, up to 600 or 700 feet. Granitic detritus is lodged in various parts of the Penine chain at much greater elevations, not exceeding, however, 1400 feet. These deposits are seen in their most perfect state in low-lying districts, where sections are exhibited in the sea cliffs. If we trace them down the eastern coast we find them in Holderness to consist of boulder clay or till, from which the upper erratics have been stripped, with the exception of a few detached outliers of sand and gravel. In the cliffs of Cromer we have the boulder clay at the base, varying in thickness from ten to somewhat less than one hundred feet. The original thickness of the upper erratics there amounts, in their greatest developement, to nearly 300 feet. In the district north of Norwich, they have been so slightly denuded that the clay

* "On the Transportal of Erratic Boulders."—*Quart. Journ. Geol. Soc.*, vol. iv. p. 315 (1848).

is only partially exposed in the bottoms of the valleys. South of Norwich a large area of the clay is uncovered, the two great outliers of Strumpshaw and Poringland bearing witness to the mass of upper erratics which has been removed. In the valley of the Waveney, and through the centre of Suffolk, a larger area of the boulder clay is exposed, constituting the strong land district of Young's agricultural map, with numerous outliers of the gravel and sand of the upper erratics remaining upon it. Similar phenomena extend through Essex. The reconstruction of the mixed materials of the two erratic deposits along certain lines—their total removal from others, and the exposure of the red and coralline crag, the London clay, and the chalk—together with the varying depth and composition of the "warp" or unconformable superficial deposit—its depth varying with contours, and its composition with that of the beds exposed in the neighbourhood, combine to produce the rapid and intricate changes of soil which, in a former page, we have seen were attributed by Mr. Morton to variations in the mineral character of beds of the plastic clay, but which admit of no satisfactory explanation without reference to the deposits of the erratic period.

If these deposits are traced down our western coast, cliffs of varying height—composed in the lower part of boulder clay, and in the upper part of sand and gravel—present themselves in the tract between the Mersey and the Dee, and at various points from the last-named river to Conwy,* particularly near Abergele: interrupted, however, by promontories of lofty rock, on which they could not have formed, and by low alluvial districts from which they have been denuded. Similar accumulations, with similar interruptions, are found along the coast of Anglesey, from Red Wharf Bay to near Holyhead, and along both sides of the long point of Caernarvonshire, from Clynog to the neighbourhood of Criccieth. They are found also at intervals along the whole coast of South Wales, from Aberystwith to near St. David's Head—the boulder clay chiefly occurring in patches at the mouths of the small valleys of this rocky coast, and in the upper parts of the large valleys, the lower regions of which appear to have been swept clean of it.

The sections afforded by the sea cliffs exhibit the structure of the erratic tertiaries which fill depressions between the hills, and constitute small basins analogous to the larger erratic districts on the eastern side of the chalk range. The variations of soil from sand to clay through all the intermediate gradations are caused in the smaller, as well as in the larger basins, by the amount of denudation to which the erratic strata have been subject, and by

* Journ. Geol. Soc. Dublin, vol. i. part iii. p. 180.

the varying depth and composition of the unconformable deposit, or warp, spread over the denuded surface.

The lower erratics of mountainous regions do not extend to heights which we should estimate at more than 700 or 800 feet. At greater elevations, the gravel and sand of the upper erratics, which, at low elevations, rest on boulder clay, are in immediate contact with the rock. As the clay ceases at a certain height, so, at an elevation, which we estimate at somewhat more than 1500 feet, the upper erratics also cease, and are replaced by peaks of naked rock, surrounded by heaps of their own ruins in the form of angular blocks. As the phenomena at such elevations have a geological rather than an agricultural interest, we pass them over without further notice than that they are in unison with the recorded action of a polar climate on the land. The marine remains, and the far transported boulders which surround the Welch mountains, and are lodged on their flanks at considerable elevations, have not penetrated far into the interior; nevertheless there are, even in the inland valleys, considerable accumulations both of clay, gravel, and boulders, which have a local, or a modified local origin, having been derived from the neighbouring rocks, and exhibiting in most cases proofs of some degree of transportation outwards, along existing lines of drainage, but greatly above their present influence.

The most remarkable case which we have met with of an advance of the marine erratic deposits into the interior is in a small valley, at an elevation of something less than 1000 feet, transverse to the great valley of Nant Francon, and opposite to the Penrhyn slate quarry, in Caernarvonshire. We there saw fragments of granite and carboniferous limestone, accompanied, as we have good reason to believe, by marine shells, brought up from the bottom of a shaft sunk through detrital deposits to the depth of 60 feet; the rock below being clay slate, a large portion of the upper part consisting of local débris. In the valley of Nant Francon, at lower levels, the detritus is wholly local, derived from the mountains of the interior, and the rocks have in many places that rounded, polished, and grooved surface, which is an observed effect of the action of shore-ice, and also of terrestrial glaciers. The marine deposit which fills the bottom of this elevated transverse valley could only have reached it through the main valley of Nant Francon, which communicates with the sea; and as they are not found in that valley, they must have been swept out of it, either by ordinary denuding action during the process of elevation, or, as was suggested by Mr. Darwin, by the descent of glaciers after the emergence of the land. The polished and striated rocks may, therefore, be referred to the action of such glaciers, or they may be considered monuments

of marine glacial action during the period of submergence, to which we attribute the boulder clay.

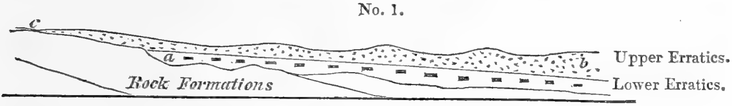
Even in districts like Norfolk, which have been wholly submerged, foreign detritus is most abundant in the lower erratics, near the mouths of valleys, or in valleys like the Waveney, open at both ends. The fragmentary matter of the upper part of closed valleys is chiefly that of the bounding rocks.

In the district between the Snowdonian chain and the Menai Straits there are extensive accumulations of gravel, loam, and boulders, destitute of marine remains, and borne outwards from the chain; granitic fragments and shells, which indicate transport inwards, being only found at one or two spots, and there *beneath* this local gravel. Near the mouth also of the great valley which descends from Snowdon to the head of Cardigan Bay, marine deposits with fragments of shells, and blocks transported from a distance, are replaced, between Criccieth and Harlech, by accumulations of local fragments derived from the interior of the chain.

On the whole, it is impossible to have traversed the interior of Wales without seeing that, beyond the influence of existing streams, there are great accumulations of detritus, more or less local, which we must attribute chiefly to the operations of this period, and which, though the materials have been derived from the neighbouring rocks, exhibit sufficient indication of transport by water to negative the doctrine of the dependence of the composition of soils on that of the rock beneath, except on steep acclivities and at great elevations. Without more extended observations, however, than have yet been made, it is impossible to form even an approximate conjecture respecting the marine or terrestrial origin of such accumulations, or to point out the districts in which the influence of the superficial deposits, or that of the subjacent rock, prevails in the soil. We have seen enough, however, to be certain that there, as elsewhere, the distribution of soils is dependent on contours; and that but for such accumulations these mountains would have been more barren than they are. One fact, which we have observed in Wales, is, that the thinner and poorer soils on the sides of hills are generally preferred, because naturally dry, to the deeper and better soils in lower situations, which require to be drained, and are therefore abandoned to their native rushes. A Welch farmer, who was asked "Why do you not drain, or ask your landlord to drain this land?" replied, "If God had intended it to be dry, it would have been made dry by nature." Another, speaking of the new agent, who had drained a large extent of fine, but wet alluvial land, said, "Upon my word, Mr. —— will spoil all our farms; we shall have no rushes to 'thatch with.'"

From Wales we will now return to the mouths of the Mersey and the Dee, and trace the erratic deposits thence into the interior, over the red sandstone plain of Lancashire and Cheshire, up to the very foot of the Penine chain, from Manchester to Congleton, and southward towards Stafford. Shells have been found at each of the two former places, and at various points in Shropshire and the adjoining counties, the most southern yet known being about three miles south of Worcester. Boulder clay occurs at greater elevations in the interior of the island than on the coast. On the Norfolk coast it is nowhere more than 100 feet above the level of the sea; but near Swaffham it attains an elevation of between 300 and 400, with a depth of 90 feet in some of the hollows in the chalk. On the other hand, the upper sand and gravel, which are nearly 300 feet thick at Trimingham Beacon, thin off on the summit of the watershed at Swaffham, so as not to exceed a thickness of 30 feet as the maximum. Similar differences occur between the levels of the boulder clay on the coast of Cheshire and in the interior, at the foot of the Penine chain. These different elevations may be explained by the advance of the coastline into the interior during subsidence of the land; the boulder clay being, as we have said, a littoral deposit. As the subsidence con-

No. 1.



tinued, this would be succeeded and covered by the upper erratic deposits of a more open sea; so that the lower erratics at *a*, in the annexed diagram, would be contemporaneous with the upper part of the upper erratics at *b*. As the subsidence proceeded, and the climatal conditions favourable to the production of boulder clay as a littoral deposit gave place to those favourable to the production of sand and shingle, the ordinary deposits of such situations, these would ultimately overlap or extend beyond the boulder clay at *c*.

Similar phenomena occur as the erratic tertiaries are traced from north to south. They are thicker in the north than in the interior of the country south of Trent, in which direction the boulder clay appears to thin off. We have seen it between Fishguard and St. David's Head, southward of which our observations have not extended on the west of the island. East of the chalk range it comes down to the neighbourhood of London, where it is cut off by the Highgate ridge. We have observed it near Desborough, in Northamptonshire, where there can be no doubt that the gravel beds described by the Dean of Llandaff, as extending from Houghton-on-the-Hill, by Market-Harborough, to Daventry,

constitute the upper erratics. The clay may be seen in some of the fresher railway cuttings near Wolverton. Dr. Mitchell has described it on the Castle Hill, six miles south of Bedford; and on the line of the Birmingham Railway, near Leighton Buzzard, resting on the lower green sand, and overlaid by gravel. He did not note the clay in Herts, but found gravel about Puckeridge, Hare Street, and Newnham, near Baldock, abounding with fragments of secondary and other transported rocks. At Ware Mill, also at Wade's Mill, he observed a few such fragments in gravel.*

In tracing the erratic blocks down the western side of England it was observed that the granitic blocks begin to decline in quantity and size south of Bridgenorth, passing off into coarse gravel, which again passes into the fine gravel and silt of the vale of Gloucester.

The erratic gravel of the south midland counties is a thinner deposit than that of the north; and among its foreign detritus, fragments, sufficiently large to merit the name of boulders, are less frequent. This circumstance, which has induced some to regard it as belonging to a different epoch, appears a natural result of formation during different portions of a protracted period of depression and elevation, both proceeding from the north; the depression greatest in the north part of the island and not complete in the southern, till the extreme glacial climate had commenced its retreat northwards; so that boulder clay was no longer a littoral deposit, and large erratic blocks were no longer transported to be embedded in the upper erratics.

Erratic Gravel of the Southern Counties—absence of Boulder Clay.—We have treated hitherto only of deposits north of the Thames. Those south of that river deviate still more than those of the south-midland counties from the northern type. South of the Thames not a trace of boulder clay has yet been found; but the chalk and the eocene tertiaries of Hants, Dorset, and parts of the adjacent counties of Kent and Sussex, are covered with a peculiar flint gravel, seldom more than 30 feet thick, and generally much less, which occurs at all heights, from 600 feet on the chalk hills to the sea level. It caps Headon-Hill, in the Isle of Wight, and the high grounds about Osborne House. It is found on the chalk near Romsey, and on all the table-lands of the eocene tertiaries: the flints of which it is composed are but slightly waterworn, and are embedded in a ferruginous, sandy, sometimes clayey base. They appear to diminish in size with every stage of descent; but, except along the river courses, are scarcely more rolled at the lower than at higher levels. This is a remarkable fact, very difficult of explanation;

* Quart. Journ. Geol. Soc., vol. iii. p. 4.

if, as seems probable, the gravel once formed a continuous stratum at the highest level at which it is found. Some very instructive sections, showing the relations of the surface soil to this gravel

No. 2.

Christchurch. Hordwell.

a Warp or surface loam. *b* Flint gravel. *c* Freshwater eocene.
d Upper Bagshot, Headon-Hill sand. *e* Barton clay, *f* Bracklesham beds } Middle Bagshots.

and the older tertiaries, are afforded by the cliffs which extend along the Hampshire coast from Christchurch to Hordwell. The gravel covers the denuded surface of the older tertiaries, and is covered by a warp, which deepens in the hollows, and thins off towards the summits, as in the annexed diagram.

We could never find anything in the gravel of Dorset and Hants but flints and fragments of stone derived from the eocene tertiaries. Shells, we believe, have never been seen in it.

In the upper part of the elephant bed at Brighton, which is a mass of fragmentary chalk, we observed a small boulder of trap; and Dr. Mantell describes water-worn blocks of granite, porphyry, slate, limestone, and tertiary sandstone in the shingle, or ancient beach, containing marine remains, on which the elephant bed rests.* The Brighton deposits bear more resemblance than any of those south of the Thames to portions of the upper erratics of Norfolk.

From the general difference of character exhibited by this southern gravel, and from its being in immediate contact with the eocene tertiaries or the chalk, the pliocene formation of the crag being absent, some geologists refer it to a more ancient epoch than that of the erratics of Norfolk, which, it will be remembered, are superior to the pliocene crag. We are inclined, however, to regard it as a modification of the upper erratics of the district north of the Thames, the modifications of composition being, perhaps, due to different conditions of climate prevailing during its formation, and perhaps to movements of disturbance, by which the strata of the chalk were fractured during its formation. It must be borne in mind that while the chalk strata north of the Thames have been thrown up with a strike from north-east to south-west, in ridges whose direction has influenced the distribution of the superficial deposit, they have an east and west strike south of the Thames. This east and west line of disturbance, which upset the chalk and tertiaries of the Isle of Wight, threw up the parallel chalk ridges of the North and South Downs, laid open the Weald

* Mantell's Geology of the South-East of England.

denudation, and broke the continuity of the eocene tertiaries, separating them into the London and Hampshire districts, is placed by Elie de Beaumont in the erratic period, *because* of its east and west strike. The direction of lines of disturbance, unsupported by other evidence, cannot be deemed conclusive of the periods when the disturbance took place, since it has been ascertained that they have in many instances been repeated along the same line at different geological epochs. There is, however, enough in the circumstances which have been mentioned to render the relations of this flint gravel to the east and west line of disturbance—to the gravel beds on the high grounds north of the Thames, and to the fluviatile deposits in the valley of the Thames, containing bones of elephants and other large mammals —an attractive subject of investigation to geologists: it is still involved in much obscurity, and can only be worked out effectually by mapping the surface variations on both sides of the Thames.*

Whatever the age of these deposits may prove to be, the fact of importance to agricultural geology is that large areas are covered, in the southern counties, with beds of gravel so deep as to exercise a great influence on the soil, which have no place on geological maps as at present constructed.

Districts most free from Erratic Deposits.—We have now extended our survey of the erratic deposits over the whole of England and Wales, with as much detail as our limits, and, we may add, the present state of geological knowledge respecting these deposits will permit. The result is, that the only large districts over which the submergence of that period can, by any possibility, be supposed not to have extended are the following:—The more elevated portions of the Cumbrian, Cambrian, and Penine chains, which exceed 1400 or 1500 feet in height—tracts which have but little agricultural value—the county of Cornwall, with parts of Devon; the more elevated portions of the oolitic ridges, particularly in the south, near the head waters of the Thames and its tributaries; and the Weald of Kent, Sussex, and Surrey. With respect to the last, which is considered by some to have enjoyed the same immunity from invasion by the erratic sea which is claimed for it from foreign conquest in the old rhyme—

"The winding vale of Holmsdale
Was never won and never shall,"

it may be remarked that, though generally free from extraneous

* Since this passage was written, papers, not yet published, on these south-eastern deposits, have been read before the Geological Society, by Sir R. Murchison, Mr. Austen, and Mr. Prestwich, which, from their conflicting views, prove how much the subject still requires investigation.

fragments, it contains more than is usually supposed. Dr. Mantell* speaks of beds of partially rolled flints as occurring not only immediately beneath the turf, on the summits, and in some of the valleys of the Downs, but also of beds of loam, clay, sand, and gravel, and other débris, spread over the surface of the regular strata throughout the interior of the country, obscuring their outcrop, and forming the immediate subsoil of the district—we may add, of course, the soil also. The flints and gravel he refers to the disintegration of the chalk; the loam and clay to the sands and clays of the Weald and the Forest ridge. He speaks also of large blocks of siliceous sandstone, belonging to no regular bed, now existing in the district, and of the ferruginous breccia of the tertiary formations as occurring in these deposits; and he designates a bed of broken and partially rolled chalk flints, resting on an eminence of Weald clay at Barecombe, as one of the few examples of such detritus lying at a distance from the chalk escarpment.

Beds of waterworn fragments of sandstone and ironstone, derived from the upper beds of the Hastings sands, are described as covering the surface of the Weald clay and iron sand at Isfield, Little Horsted, Barecombe, Wittingham, and Hamsey. We have ourselves observed chalk flints within the Weald, in a cutting on the Brighton Railway.

With respect to Cornwall and Devon, it may be remarked that the absence of erratic deposits from certain tracts by no means proves that they were not submerged. In districts respecting which there can be no doubt that they were beneath the erratic sea, from detached portions of both upper and lower erratics still remaining in them—as in some of the larger valleys of South Wales—there are spaces covered with the reconstructed detritus of the two brought down to lower levels, and other spaces quite clear of all detritus. With these completely denuded spaces we may compare those districts of England which are free from erratic deposits, viewing the whole island as a district submerged during the erratic period.

Even in Devon and Cornwall, Sir H. De la Beche describes transported gravel as occupying detached portions of the surface, though he is doubtful to what portion of the tertiary era they are to be referred. They indicate transportal from the north.

Distribution of Soils, as laid down by Agricultural Writers.—Having closed the geological evidence respecting the presence of erratic deposits over by far the greater portion of England and Wales, we proceed to the agricultural evidence respecting variations of soil, which cannot be connected with variations in the

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* Geology of the South-East of England.

mineral characters of the substrata on which they rest. This evidence will be derived from the Reports to the Board of Agriculture, and from other agricultural writers of the period, and also from the essays on the farming of certain counties which have from time to time appeared in the Journal of the Royal Agricultural Society.

The earlier writings of Young and other reporters to the Board of Agriculture, made before * Smith's views respecting strata and soils became known, are the most valuable as a contribution—slight as it is—to a knowledge of the distribution of soils, because in the districts described they give a general outline of the areas occupied by certain kinds of soil, founded on observations of the soil itself, without reference to the distribution of the rock formations; whereas in the later writers a disposition may sometimes be observed to make the soils accommodate themselves to the Procrustean bed of the geological maps. Among those reporters, however, whose maps agree most with geological maps, there are some who assert that the substrata only mark the general outlines of agricultural districts, and that within these areas there are numerous variations of soil independent of the substrata.

The earlier writers, in describing the counties of which they treat, first carve out certain districts of clay, sand, and loam, of which they observe that, in each of them, clay, sand, or loam, respectively, prevails, not without many exceptions; and they throw the remainder, not unfrequently the larger portion of the county, into a district "of various soils," which are described as intermixed with so much irregularity, and in such small portions, that no separation can be made.

Young says of the variations of soil in the strong land district of his map of Suffolk, that a rule, to which he knows few excep-

* "Ten years afterwards he (Smith) circulated proposals for publishing a treatise on the Geology of England, to be accompanied by a coloured map and sections; and in the interval he had freely communicated the information he possessed in many quarters, till it became by oral diffusion the common property of English geologists, and thus contributed to the progress of the science in many quarters where the author was little known. In the same interval, between 1790 and 1800, several volumes of reports were published by the Board of Agriculture, many of them containing much local geological information, and *to this Board must undoubtedly be ascribed the honour of having produced the earliest geological maps of any part of England,* for its first series of reports, published in 1794, contains very adequate geological maps of the North Riding of Yorkshire, of Derbyshire, and Nottinghamshire, and a less perfect one of Devonshire. That of Kent, published 1796, has a regular geological map of that county, which indeed, after the treatise of Packe in the beginning of the century, it was easy to construct. Between this date and 1813 the same Board has also given useful maps of Sussex, Surrey, Berks, Bedford, Gloucester, Wilts, Lincoln, Durham, and Cheshire, besides publishing a second report on Derbyshire, by Farey, dedicated exclusively to its mineralogy."—*Introduction to Outlines of Geology of England and Wales,* by Conybeare and Phillips.

tions, is, that wherever there are rivers in it, the slopes hanging to the vales through which they run, and the bottoms themselves, are of a superior quality, composed in general of rich friable loam, and that this holds good of many inconsiderable streams which fall into the larger rivers. The same remark, with modifications arising out of the different structure of other districts, is repeated, as will be seen hereafter, by several of the writers who describe other counties.

The statement is nearly identical with that in the paper on the Geology of Norfolk, in the seventh volume of the Society's Journal, which asserts the dependence of the variations of soil on contours. Let us now test the truth of the opposite doctrine, which refers these variations to variations in the composition of the formations of our geological maps, by tracing them through the maps and descriptions of the agricultural writers. We will commence with the chalk, one of the most important of these formations. The whole eastern side of England, from the confines of Devonshire and Dorsetshire on the south, to the north-west angle of Norfolk, may be regarded as a great sheet of chalk, covered more or less by tertiary strata of all ages, and broken through and denuded, along an east and west line of disturbance, in the Weald of Kent and the Vale of Wardour. A smaller area reappears north of the Wash, on the eastern side of Lincolnshire and Yorkshire, partially covered by the erratic tertiaries. It will, therefore, be a convenient arrangement to notice the variations of soil on the districts of the older tertiaries in tracing the soils of the area assigned to the chalk on geological maps.

By the prevalent hypothesis, the soils of that area should be white and calcareous. So much, however, are such soils the exception rather than the rule, that from Yorkshire to Cambridgeshire they are scarcely mentioned; and through the remainder of the chalk range they are described as confined to certain elevations and forms of surface, that is to say, they are dependent on contours.

The Wolds of Yorkshire are divided into the Northern and Southern Wolds, their height above the sea being 812 feet in the north, and 500 feet at the southern termination of the southern Wolds. Upon the elevated plains of the northern Wolds, we are told by the agricultural writers, that there is a uniform covering of diluvial matter, 18 to 24 inches thick, consisting of a deep-coloured, loamy soil, with an occasional mixture of clay.* Professor Phillips states, in his 'Geology of Yorkshire,' that the boulder clay or till of Holderness runs up some of the valleys of the Wolds. His coast-sections show a considerable thickness of

* Legard, Journ. Roy. Agri. Soc., vol. ix. p. 86; Strickland, Rep. Bd. of Agri.

it at various heights up to more than 350 feet on the outcrop of the chalk at Speeton Cliff. According to Strickland and Marshall,* the surface of the lower Wolds consists of a light, calcareous, friable loam, 3 to 10 inches deep. Mr. Spence, however, in the 'Transactions of the Yorkshire Agricultural Society,' cited by Mr. Legard, has proved that the soil does not partake so much of the nature of the rock beneath it as was formerly thought, and that it contains at the utmost 5 per cent. of calcareous matter—very often not more than 2 per cent. On the thin soils this may have been brought up by the plough. Extensive gravel beds are described as occurring in the valleys of the Wolds, by Mr. Legard—such gravel being thinly spread, a mile broad, in Dalestown Valley, where it forms a very useful convertible soil; while in the narrower valley of Thixendale, where it is three feet deep, and barely covered by a thin coat of soil, it requires frequent dunging and dressing.

Of the Wolds of Lincolnshire, Young says, that it would be a waste of time to attempt to describe any distinctions in their soils. All he saw or heard of were a "sandy loam on a chalk bottom, the quality very various, from poor sand, producing heath (*Erica vulgaris*), to rich deep fertile loams, that yield capital crops of wheat, and some even beans. On the sides of the hills near Louth great spaces were covered with rushes and springs."

In Norfolk, the area coloured as chalk on most of our geological maps is covered by the good and poor sandy districts, and part of the district of various loams, of Young's agricultural map. In its range through Suffolk it forms his western sand district, which consists chiefly of blowing sands, with some tracts of loamy sand and sandy loam. Chalk is also the substratum under a great part of his district of strong loams—a tract bounded on the east and south by Halesworth, Woodbridge, Sudbury, Clare, and Haverill, where the soils rest on boulder clay, marked on some geological maps as alluvial and diluvial deposits; on others, but erroneously, as plastic clay. The chalk of Cambridgeshire is described by Mr. Jonas † as forming the substratum of the eastern part of the county, cropping out in its centre, and extending by Ickleton, Meldreth, Royston, Newton, Gogmagog Hill, and Newmarket, to the boundary of Suffolk—the lower chalk in its outcrop at Cherry Hinton, Burwell, and Swaffham Bulbeck affording splendid land (white), of a soapy nature, and excellent for wheat. He describes the whole of the chalk as covered with diluvial deposits of sand, gravel, loam, tenacious clays, and various other strata, either in beds uninterrupted for considerable spaces, or in every variety of intermixture. Gooch's description, in the

* Marshall's Agriculture of Yorkshire. † Journ. Roy. Agri. Soc., vol. vii. p. 85.

Report to the Board of Agriculture, is to the same effect, as to the variety of soils on the chalk, besides the deep white loam of the outcrop of the lower chalk; and his map represents a stripe of chalk running through the centre of the county, with tracts of clay on the east and west. The eastern tract must be a continuation of the till or boulder clay of Norfolk and Suffolk. The western tract consists in part of gault and Oxford clay where they are exposed, and in part of the brown clay of Cambridgeshire, a variety of till west of the chalk ridge. One of the sections given by Mr. Jonas shows a considerable depth of the brown erratic clay on the gault and green sand between Orwell Gap and Gransden.

In Essex, Young's map only allows to the chalk district a small angle of the county adjoining to Cambridgeshire west of Saffron Walden. "The substratum of the whole county," he says, "is chalk at various depths, which begins to appear within a mile of Walden." About Audley End he describes the hills as chalk, the vales good loam and gravel, but with variations, the soil on the hills not more than five inches deep, and liable to burn in dry weather. His other varieties of soil on the chalk are wet soils; cold and heavy soils; soils on a basis of gravel; good turnip land in the vales and lower slopes, generally dry and good.

Our geological maps of Hertfordshire assign to the chalk all that area north of a line drawn from Bishop's Stortford through Sawbridgeworth, Ware, Hertford, Hatfield, St. Alban's, Hemel Hempstead, and Watford, with the exception of a tongue of the plastic series extending from St. Alban's as far as Kingsbourne in the direction of Luton. The chalk, however, is so covered with the superficial deposits that Young's agricultural map only exhibits as his chalk district, the outcrop of that rock in the N.E. of the county from Royston by Baldock, and in the southern extremity that indentation of green sand which on the geological maps runs in at Hitchin. In this tract, he says, the surface soil consists of two varieties—chalk, without other mixture than that which it has received from ages of cultivation, and *marme*, a white marl containing an admixture of clay—both good soils, but the latter the best. A large portion of the chalk of our geological maps is covered by his districts of loam and clay, which, with his chalk district before described, constitute the principal agricultural areas into which he divides the county. He observes of them—"I should guard the reader against the idea that this is an accurate discrimination. The truth is, that the soils in this county mix and run into one another in such a remarkable manner, that, except in the case of the chalk, and that singularly infertile land which I term gravel, they are named and traced with a good deal of uncertainty, not for want, I trust, of attention in making the observations, but from the varying qualities of the

soils." He divides his loams into sandy and flinty, the latter in some parts tenacious, but kept loose and friable by the flints and due tillage.

"Some tracts," he adds, "from a degree of wetness, are called clays, but improperly; indeed, there is scarcely a more general error in various parts of the kingdom than that of giving the term to loams of various descriptions. The district of loams is every where under the turnip course, and the crops are fed on the land—a circumstance sufficient to show that the soil is in some degree removed from the real clay of farmers, and without any similarity to the clay of chemists, with which we have nothing to do in agricultural inquiries." This district of loams lies partly on the chalk district, partly on the plastic and London clay, of our geological maps. A line drawn from Ware to the extremity of the county, in the direction of Baldock, is very nearly the boundary between his loams and eastern clay district. "This last nearly resembles the contiguous claylands of Essex, being rather a strong, wet loam on a stiff basis of clay marl, both, but especially the last, in a great measure free from stone and flint, so generally abounding in the county." It is situated partly on the chalk of the geological maps, and appears to answer to that district described by Mr. Baker * in Essex, which, taking Dunmow as a centre, extends, he says, to Cambridgeshire, Hertford, Epping, and nearly to Chelmsford, subject to some variations. It is evidently, from his description, an erratic district in which the surface soils are based on a continuation of the till of Norfolk and Suffolk.

Young's southern clay district of Hertfordshire is represented on geological maps by that portion of the London clay which is cut off between the boundary of Middlesex and a line drawn from Barnet to Elstree. His district of gravel with smooth blue pebbles, whose sterility he paints in such dark colours from personal experience in the cultivation of it, is evidently the outcrop of a pebble bed of the plastic series, with masses of the Hertfordshire pudding stone, celebrated for its beauty when cut and polished. A joke was current some twenty years ago among the farmers at Uxbridge market, respecting a similar tract which an auctioneer had been tempted to buy by its low price, and to which, on putting it up for sale again, after expending much money upon it, he could give no better character than that it was an "improvable property." Such barren tracts, however, have sometimes a value independent of their agricultural capabilities. That property is now covered with villas and ornamental plantations.

The map appended to Mavor's Report on Berkshire professes

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* Journ. Roy. Agri. Soc., vol. v., p. 1.

to indicate the four natural divisions of the county, viz. the Vale of the White Horse Hills, a continuation of the chalk district of the Chilterns, the valley of the Kennet, and the Forest.

The chalk hills are described as running through the centre of the county, from Ashbury on the W., to Shealley on the E., where the Thames flows through a gorge in the chalk. The more western parts, from their abruptness towards the Vale of White Horse, and from their general deficiency of soil, are described as unfit for cultivation, but affording excellent sheep pasture: surface a blackish light earth on chalk. This down-district terminates with Isley Down on the E. The south sides of the chalk hills towards the Vale of Kennet afford, according to the same authority, some intermediate tracts of considerable fertility, consisting of flints, chalk, loam, and gravel, but almost wholly on a chalky substratum, which extends on both sides of the Lambourn towards Hungerford, and, keeping at an irregular distance from the line of the Kennet, winds round to meet the Thames as far as Cookham. We have now reached the great central area of the chalk—its *patria* as Pennant called it—on which all the branches of chalk hills converge. In this district, which constitutes the elevated platform of Marlborough Downs, Salisbury Plain, and the Hampshire Hills, the chalk attains its greatest elevation in England, being 1011 feet above the sea at Inkpen Beacon. The Report on Wiltshire is by Mr. Davis, of Longleat, a celebrated land agent, the same who, on hearing Smith's explanation of the connexion between the course of agriculture pursued on the Wiltshire hills and vales, and their geological structure, exclaimed, "That is the only way to learn the true value of land." "The soil of this county," he says, "though various, is, to a certain degree, uniform. The hills are chalk, with its usual accompaniment of flint; and in general the land on the sides of the hills, from which the flints have been washed, is a chalky loam, or rather dissolved chalk. In the valleys through which the rivers run are beds of broken flints, covered with the black earth washed from the sides of the hills above." Hence we may observe that the white land prevails near the sources of the rivulets, where the hills are steepest, and the flinty loams near the junction of the hills, where the land is flattest. The sides of the hills where they have been most washed have the thinnest and weakest soil, and the tops of the hills, which have been little if at all washed, have frequently the strongest and deepest land.

From this it appears that in this elevated region, above the limits to which the lower erratic tertiaries usually extend, and at about two-thirds of that elevation which we have estimated as the limit of the upper erratics in the north, there are traces of a thin

deposit on the summits of the hills. It appears also that in a district where a large portion of the soils are local, that is, derived exclusively from the rock on which they rest, the same fact prevails, which has been repeatedly pointed out in lower regions—the dependence of the variations of soil on contours.

The soils of the chalk of Hampshire are described by Vancouver. He remarks that "however diversified the surface of a county may be, it is the uniformity of the substratum which must generally mark the extent of such divisions as may be required for agricultural purposes." The reason which he assigns for this is that the changes which the soil undergoes from cultivation and the action of the atmosphere, do not extend to the substratum, which maintains its original condition. He does not explain, however, how, on this hypothesis, variations of soil are produced on the same stratum, without any variation in its mineral character or in the atmospheric action to which different parts of it have been exposed, or in the cultivation to which it has been subject.

On the principle of classification adopted, his geological districts agree nearly with the geological areas which fall within the limits of the county, though not so closely as his theory requires.

He observes of his chalk district that, notwithstanding the uniformity in its internal composition and structure, which consists of an unbroken rock of chalk, the soils covering its surface are so much blended as to require much attention to describe them in such a manner as to make their varieties intelligible.

He divides them into—

1. The soils of the higher parts of some of the Downs—light, dry, friable, sandy loams, of moderate depth, provincially called hazel, resting on chalk rubble, or partially dissolved chalk, and affording in their natural state short but sweet sheep pasture, but liable, on the brows and sides of the hills, to be washed away when under cultivation.

2. A black vegetable mould, of moderate depth, on a bed of flints and rubble, which separates it from the chalk. When hard stocked with sheep it affords a very sweet herbage, but is liable to be overrun with dwarf furze when grazed as cow common.

3. A thin grey loam almost immediately on a bed of firm chalk, affording sheep pasture, generally of good quality—more liable to be affected by drought than the two preceding, and requiring hard-stocking to preserve the sweetness of the herbage.

4. A deep, strong, red, flinty loam, from 8 to 10 feet, upon, and partially dipping into,* the chalk. This variety is usually found on the flat tops of the lesser eminences. It is described

* That is, filling pipes and furrows in the chalk, like those shown in the diagram.

as deriving benefit from chalking, which has no effect on 1, 2, and 3; from its depth it is liable to be wet, but is capable, after chalking, of producing good wheat and a fine sample of barley.

5. A fifth class is found on the brows and sides of the same description of hills, contains less loam, and is mixed, very frequently, with dry, harsh sand, and small gravel. It is a warm subsoil, producing early vegetation, and is applied generally to the culture of wheat, turnips, barley, and artificial grasses. Of the higher part of the chalk district generally, he says that it has the appearance of a level plain, broken into many irregular parts, and intersected by deep hollows, through which the streams take their course. Considerable tracts of meadow and pasture are found along the valleys in which these flow. In them the greater portion of the population is congregated. These alluvial tracts consist of alluvial soil or moor, on a strong calcareous loam, sometimes covered with sand, or fine gravel, or large bodies of peat. It is observed that in proportion as the moory covering is combined with the alluvial sediment, is its capacity for improvement. To these varieties he adds the strong flinty loams, and hazel loam, covering the chalk of Portsdown Hill, and resting in the islands and low ground frequently on clay. The varieties of soil on the chalk of the Isle of Wight are described as the same as in the other parts of Hampshire. The author lays down two districts of sand and gravel in Hampshire. That on the south consists of the eocene tertiaries of the New Forest, that on the east of the green sand strata of Woolmer and Alice Holt Forests. He found great difficulty in determining the exact boundary between these and the chalk district, by reason of the numerous veins of sand and gravel, and bodies of clay, loam, marl, and brick-earth, and declares it to be impossible without a particular examination of each field. We can, from experience, bear testimony to the difficulty of doing this, even with such an examination, without digging and boring, when the junction of the chalk and tertiaries takes place on a flat or a long slope.

With respect to his southern forest tract we have already shown that the variations of its soils depend, except on abrupt escarpments, on the covering of flint gravel, and the depth and composition of the "warp" upon that gravel, more than upon the mineral variations of the strata. The place of those strata in the series, long imperfectly understood, has lately been cleared up in a satisfactory manner by Mr. Prestwich.* On geological maps they have hitherto been marked as upper marine, London clay, and plastic clay. The upper marine is nothing more than a deep bed of erratic flint gravel, not confined to the area there laid down, but

* Quarterly Journal Geol. Soc., vol. iii. p. 355.

spread, more or less, over the whole district. The greater portion of the New Forest, marked as London clay, is a continuation of the freshwater or rather estuary strata of the Isle of Wight, which reappear in Hordwell Cliff. The attenuated representatives of the London and plastic clay—the former under the form of a ferruginous sandy loam—occupy a very narrow band bordering the chalk. The remainder of the space, coloured on existing geological maps as London and plastic clay, consists of sands and clays, which are the equivalents of the upper, middle, and lower Bagshot beds, of the London tertiary district, established by Mr. Prestwich. To the lower Bagshots belong the sands and white clays of Poole and Corfe Castle; to the middle Bagshots, the clays of Barton, and the sandy clays and clayey sands of Christchurch Head; to the upper Bagshots, the glass-house sand of Headon Hill, in the Isle of Wight, which is there immediately below the freshwater clays and marls, and which reappears beneath those strata and above the Barton clay in Hordwell Cliff.

But to return to the chalk. It remains to trace the variations of soil upon it, through Dorsetshire and on the North and South Downs, as laid down by agricultural authorities. The 'Report on Dorsetshire,' to the Board of Agriculture, is by Stevenson. He tells us that the soil of the more elevated parts of the chalk district is a thin loam, incumbent on rubbly chalk, below which is compact chalk; and that in those cases in which the soil is only two or three inches deep, the land cannot be ploughed to advantage, as the mixture of the loose chalk is pernicious. He adds, that the poorest parts of the Downs are the steep acclivities which overlook the vale of Blackmore, and the most fertile those which border the sandy district (eocene tertiaries) between Wimborne and Dorchester. In some places flints are numerous. Between Evershot and Cerne he describes deep beds of gravel, flints, and clay, as covering the chalk. Wherever the strata incumbent on the chalk consist of deep sand and gravel, the surface is generally covered with furze or heath, the latter seldom appearing where the chalk is at no great depth. The vales are in general covered with deep gravel, loam, or clay, "which may be supposed to have been washed from the contiguous hills in the general inundation. Some people," he adds, "seem to entertain the opinion that the natural soil, or vegetable mould, is originally of the same nature as the substratum, below the usual depth of ploughing; but the appearance of the chalky districts would induce a belief that the cultivated soil was the last sediment of the water which formerly covered the earth." He infers, from the appearance of the Celtic and Roman earthworks—which are, in many instances, as bare of vegetation as if they had

been thrown up but a few years—that the loamy covering does not increase, and, on the other hand, that the portion of clay contained in the soils lying on the chalk does not diminish by sinking into the rock with the rain-water, as clay is generally more plentiful on such soils than in those lying on the sandy strata of other countries.

It has been already observed that the counties of Kent and Sussex form a district in which the superficial deposits are very slightly developed, and which some geologists suppose not to have been submerged at all during the period of the erratic tertiaries. Even here, however, the Reports to the Board of Agriculture prove that dependence of the variations of soil upon the configuration of the surface, which has been repeatedly noticed in other districts. The variations on the Sussex chalk as described by Young are—1. A thin hazel mould, on rubbly or dissolved chalk, on the summits of the highest downs; 2. Accumulations of flints covered with vegetable soil; 3. The soil deepening on the slopes till it becomes everywhere, at the bottom, an excellent loam, 9 or 10 inches deep, on a hard rock of chalk, "broken and mixed with loam in the interstices" (*i.e.* pipes and furrows) to the depth of some feet; 4. Strong red loam, some feet deep, even on the tops of a considerable portion of the hills, between the Cuckmere river and Eastbourne, rather cold and wet, but, when dressed with chalk, extremely productive.

The description of the soils on the chalk of Kent and Surrey, by Boys and Stevenson, is to the same effect as regards the dependence of their variations on contours. In the isle of Thanet we are told of loose, dry, chalky mould, with a mixture of small flints, 6 to 8 inches deep, on the summits of ridges 60 feet above the sea; of dry loamy soils, 1 to 3 feet deep, with less chalk, and of much better quality, in the vales—of good soil of the same kind and depth, even on the hills of the west end of the island—and of deep sandy loams, the best land of all, on the south side between Ramsgate and Monkton.

The open district between Canterbury, and Dover and Deal, is described as so various that no parish or farm is similar in all its parts. Five varieties are enumerated:—1. Chalky soils on the tops and sides of the ridges, with a slight admixture in some places of flints, in others of black light mould (provincially *black hover*), the last the most unproductive soil in the district; 2. Loamy soils, 6 to 10 inches deep, on a red soft clay or brick earth, 3 to 7 feet deep, under which is generally a layer of chalky marl, and then the chalk rock, a soil easily worked, and productive both of corn and grass, if well managed; 3. "Strong cledge" on the tops of some of

the hills, a tenacious clayey soil, with a small portion of flints, and in some places small patches of chalk. When wet it sticks like birdlime; and when thoroughly dry, the soil is so hard that it cannot be broken with the heaviest roll; difficult to work, except between wet and dry, it yields good crops of wheat, beans, clover, and oats, in favourable seasons, if well managed, but in seasons unkindly for working it, and in dry summers, is very unproductive; 4. The hazel mould, a light soil on a clay bottom, more or less mixed with flints and sand, dry and kindly for wheat, barley, and clover. Beans are sometimes liable to blight on it, and so is wheat after beans or peas, particularly the latter; 5. Stiff clay on the tops of the hills. This soil is generally wet from rains, not from springs. It has sometimes a layer of yellow clay between the surface soil and the rock; 6. Flinty soils occur only in small tracts in the valleys about Dover, Stockbury, and Maidstone, covered with hardly any mould, difficult to plough, but when well managed, and with plenty of manure, productive of wheat, barley, and beans. There are but small quantities of gravelly and sandy soils in this district; but in West Kent, in addition to the varieties above described, there are gravelly soils, about 6 inches deep, on a subsoil of rocky gravel or sand, about Dartford, on the skirts of the chalk or tertiary district.

Stevenson commences his Report on Surrey with complaints of the difficulty of describing soils; because, in the first place, the terms by which they are designated are so vague and loose that to most readers they either convey no meaning at all, or a meaning the very opposite to that intended; and, secondly, because of the great variety of soils occurring in a small space, and their rapid and abrupt changes. His varieties are—1. "*Marme,* or calcareous loam," explained to be a deep hazel loam, lying on chalk, and varying in depth with the elevation; very deep at the base of the hills, and thinning off to 3 or 4 inches, in ascending to the downs. When deep there is no drawback to its fertility; when shallow, pale, and inclining to clay, it is considered backward in the spring. It forms a narrow band, extending, on the north side of the chalk hills, from Croydon to Guildford.

2. In those parts of the range which are broken by valleys there are loams not nearly so brown or so friable, much thinner, and intermixed with flints. They are considered intermediate between No. 1 and No. 3.

3. These soils are found more or less on all the sloping surfaces of the chalk to the east of the Mole, and cover nearly the whole of them, when it contracts to a single ridge west of that river. In some places the soil is nearly concealed by flints, and the subsoil is in general composed of flints, chalk, rubble, or chalk. If these soils were not on a calcareous base, and kept

friable by the fragments of chalk brought up by the plough, he considers that they would form a thin, tough, and cold clay.

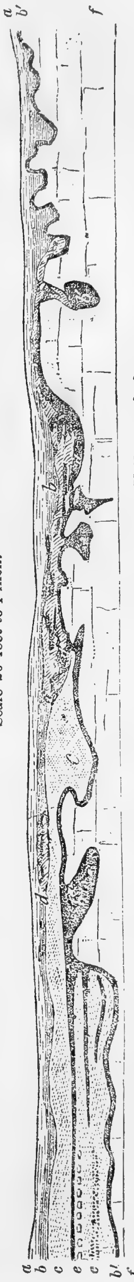
4. A tough red clay with flints, lying on the flat summits of the Downs above Reigate, and south of a bed of ferruginous sand, without any chalk, which, by the description given of it, appears to be a small outlier of the sands of the plastic series.

5. Soils composed exclusively of chalk or rubbly chalk, very slightly covered with earth, are confined to the southern escarpment of the Downs. When the hills are very abrupt, the chalk rises completely to the surface; and it is remarked that a greater extent of such soil is exhibited there, under arable culture, than in any other part of the kingdom.

On a general review of the soils on the whole of the chalk range, as described by agricultural writers, we find large tracts of it covered with every variety of soil—from sand to clay, from fertile to unproductive—and no mention of white soils till we reach Cambridgeshire. Thence, through the remainder of the district, they are partially distributed, being confined to the heads of valleys, to steep escarpments, and to the loftiest summits. The varieties of non-calcareous soils on the chalk appear from the descriptions to be no less dependent than the white soils on contours. We refer them to aqueous action of some kind or other, by which matter extraneous to the chalk has been spread over its surface by such action at the close of the tertiary era. Those geologists who have adopted the opinion that soils are derived exclusively from the rocks on which they rest, and that they are the result of ordinary atmospheric action, find the soils on the chalk a great stumbling-block. They escape it by supposing that the loam, clay, sand, and angular flints have been derived from

Section in the Road by the Parsonage of Hartley, near Dartford, Kent.

Scale 20 feet to 1 inch.



a, a. Clay loam, with numerous unabraded flints and pebbles of the eocene strata, passing downwards into *b*.
b, b. Dark ferruginous clay.
b', b', b', b', b'. Dark ferruginous clay, with flints and eocene pebbles, in contact with the chalk.
c, c, c. Yellow sandy loam.
d, d, d. Reconstructed chalk, with patches of clay.
e. A seam of small eocene pebbles, 6 to 10 inches thick.
e'. A layer of larger pebbles.
f. Chalk.

the chalk—that the calcareous matter was dissolved by the carbonic acid mixed with rain-water, and carried off in the form of supercarbonate of lime; while the siliceous and argillaceous particles of the chalk, and its flints, remained behind, as on a filter. The rapid changes in the composition of the surface soil from sand to clay, and the intermixture of white calcareous soils with dark-coloured non calcareous soils, furnish a strong argument against this assumption. If it were true, the composition of the substratum of chalk should vary with the varying composition of the soil, which is not the case; and it is a palpable absurdity to suppose that atmospheric action would have dissolved all the calcareous matter out of a considerable depth of chalk, and yet have left calcareous soils and chalk rubble undissolved. There are, however, positive proofs of aqueous transport in these soils, in the presence of alternating deposits of tough clay and sandy loam, of different colours and tenacity, together with fragmentary chalk, and layers of pebbles derived from the eocene tertiaries, large angular flints being dispersed irregularly through the whole series. The preceding diagram, p. 489, exhibiting a case of this kind, is extracted from a paper recently published in the 'Quarterly Journal of the Geological Society'—On the Origin of the Soils which cover the Chalk of Kent (vol. vii. p. 35), and for the use of which the Journal Committee are indebted to the kindness of the Geological Society.

Again we draw attention to the fact that these appearances, which are general in other chalk districts, are found in Kent, in a district in which some geologists consider that there are no traces of marine action more recent than that of the eocene or miocene tertiaries. We have gone into these details respecting the soils upon the chalk, because they prove, by the independent testimony of a number of agricultural observers, the existence of a great variety of soils on a rock of very uniform mineral character, and because they prove those variations to depend not upon the composition of the rock on which they rest, so much as upon elevation and form of surface. We have collected evidence showing equal variations in the soils on the strata below the chalk, in which the changes are partly due to the superficial deposits, and partly to varying mineral characters in the rock formations. It would require, however, a volume rather than an essay to do justice to the subject. There is, moreover, a deficiency of information sufficiently precise to permit the variations of soil to be traced in each case to their respective causes, without a special examination of an extensive district for that purpose.

Greensand.—The subdivisions of the greensand are usually considered the upper and lower greensand, with the gault interposed between them. To these must be added the red chalk of

Yorkshire and Lincolnshire, now proved to belong to this part of the series. The greensand, as at present constituted, is a compound as incongruous as the great image with a head of gold and feet of miry clay. Connected zoologically with the chalk, and forming part of the cretaceous group, it is not easily separable, in its lower portions, from the local wealden beneath it. There are few of the secondary strata which undergo greater changes horizontally within short distances. The gault is at one place lost in the upper greensand; at another the greensand is replaced by the gault; at a third both appear to merge in the chalk. Who will venture to assign agricultural characters to such a Proteus, even excluding the superficial deposits by which it is frequently covered? Mr. Morton ascribes its fertility, in the Vale of White Horse, to a thin covering of the chalk-marl and greensand, and admits a considerable intermixture of angular and rolled flints in the soils which cover it in its range through Oxfordshire, Buckinghamshire, and Bedfordshire. In Norfolk the gault exists only as a thin band, so covered with the erratic deposits that it only appears as a few small disconnected patches with the red chalk above and the carstone below. Further north its geological relations become still more obscure, and descriptions of its agricultural characters perfectly unintelligible. In Cambridge and Huntingdonshire it appears impossible to draw a line between those of the gault and those of the Kimmeridge and Oxford clay.

If we confine our attention to the lower greensand, in districts the most free from superficial accumulations, we find on it the extremes of barrenness and fertility. Dersingham Heath, Norfolk, Leith Hill and Hindhead, Surrey, Woolmer Forest, Hampshire, are on the same part of the series as the productive orchards and hop-grounds of the vale of Maidstone, and the rich grazing-grounds of the vale of Aylesbury. They who point out the gardens of Sandey and Biggleswade as instances of greensand fertility, state at the same time that it is in a great measure the result of superior cultivation; while other agricultural authorities say that the fertility is only present where a deep soil has accumulated from the wash of the neighbouring hills.

The Oolites and Lias.—In tracing the oolites from Yorkshire to the south, we find, in many instances, a close coincidence between established agricultural districts and geological areas. In others all the formations between the chalk and the lias are blended into one district, with the proviso that it contains a variety of soils too numerous to be traced more particularly. In some counties no agricultural districts are laid down on the maps, but characters indicating loam, clay, gravel, &c., are scattered irregularly, and without reference to the strata, over those parts

occupied on geological maps by different formations. In others political boundaries only are given, and the varieties of soil, under their local names, are enumerated by parishes.

In Yorkshire we can readily identify the eastern moorlands, the tabular hills, the vales of Pickering and Cleveland, with the lower oolites, the coralline oolite, the Kimmeridge clay, and the lias. In Lincolnshire, on the other hand, Young has but two divisions west of the chalk, namely, the upper part of the lower oolite on Lincoln Heath, and a district of various soils, comprising the out-crops of all the strata between the chalk and the new red. Stone, who made a second report on that county, disposes of the varieties of soil in a more summary manner, by the declaration that Young's descriptions do not comprise one-fiftieth part of the soils to be found there, and that a man who knew them well, and was not fond of much writing, would not waste his time and paper on them, unless he was able to be more particular. The western clay district of the Cambridgeshire agricultural map includes the brown clay or till of the western side of the chalk ridge, and the outcrops of the gault and Kimmeridge and Oxford clay. In Oxfordshire we have three geological areas, tolerably well defined, subject to internal variations: the red soils of the lower oolites—"the glory of the county,"—the cornbrash, and between that and the chalk, the usual resource of a district of "various soils" occupying two-thirds of the entire county.

It was on the coralline oolite of the tabular hills at Hackness* that Smith achieved one of his geological triumphs, described by Sir John Johnston. Smith's map of the Hackness estate proves two points of great importance—the necessity of indicating on maps intended to be useful for agricultural purposes, the mineral characters of even the minor subdivisions of a formation, and of indicating also the areas covered by remains of the erratic tertiaries, even in districts from which they have been most denuded, and in which the influence of the substrata on the soil is at its maximum.

The productiveness or unproductiveness of certain fields at Hackness was found to depend on the calcareous or non-calcareous character of the oolite strata on which they rested; while on a neighbouring height an outlier of the erratic tertiaries not only modified the usual agricultural character of the rock which it covered, but had thrown out springs, which had led other managers of the estate to a considerable expense in sinking for water on neighbouring hills, in which, from the absence of this deposit, it was only to be met with at great depths.

If the erratic deposits were thus found by Smith to exercise

* Journal of the Royal Agricultural Society, vol. i. p. 273.

partially an important influence on the summits of some of the tabular hills, they are found by other observers to exercise a more general influence on the soil at their base. The vale of Pickering has a general covering, according to Phillips (Geology of Yorkshire), of diluvial clay and pebbles. The soil of the clay district of Cleveland is said by Mr. Melbourne to consist of a somewhat flat stratum of diluvium, principally dissolved lias, resting upon lias. It has been shown in the former part of this essay that the lias in the counties of Rutland, Leicester, and Warwick, is covered by deep erratic deposits of very mixed materials. Mr. Bravender* lays it down as a general rule, applicable to all the divisions of the lias, that their fertility depends on the presence or absence of a diluvial covering. He adduces the neighbourhood of Cheltenham as an instance of fertility, and large portions of the Vale of Gloucester as an instance of unproductiveness, from this cause.

One of the most remarkable features in the agricultural geology of the oolites is the extensive area through which there is an undoubted intimate connexion between the strata of the oolitic group and the soil. In the county of Rutland, which is much covered by erratic deposits, this in a great measure disappears. The author of the Report on that county, the smallest in England, enumerates no less than twenty-five local names of soils there, and expresses his conviction that, numerous as they are, the actual varieties of soil are quite as numerous. The derivation of the soil on so much of these lower oolites from the subjacent rock, in the counties of Gloucester, Oxford, Northampton, and Yorkshire, may be considered a proof of the truth of the generalisation that the distribution of soils is dependent on contours. On that range phenomena are exhibited on a large scale, which numerous observers have proved to exist on a smaller scale on the chalk hills. It will be remembered, that white soils derived immediately from the chalk, were confined in the south of England to steep escarpments, or to elevations of 800 or 1000 feet. It is at such elevations, or on steep escarpments, that oolitic soils, become the rule on the oolitic hills. In Oxfordshire, Epwell Hill, belonging to this formation, is 700 feet above the sea; Arbury Hill, Northamptonshire, 800 feet. In the Cotswolds there are Lansdown Hill 812, Stow on the Wold 804, Broadway 1086, and Clever Hill 1134 feet. In the eastern Moorlands of Yorkshire are several hills 900 to 1000 feet high, the highest reaching to 1485 feet.

New Red Sandstone.—In the Reports to the Board of Agriculture the soils on the New Red Sandstone of the vale of York are described in great detail. According to Mr. Legard these varia-

* Journ. Geol. Soc.

tions are to be ascribed to the erratic tertiaries, for he says the rock is covered to such a depth with diluvial matter, that for all practical purposes it may be dismissed from consideration. The same remark applies to that large area of the New Red Sandstone which extends from Lancaster to near Worcester, and up to the edge of the Penine chain. The variations of soil shown on the map which accompanies Holland's Report on Cheshire are clearly to be ascribed to the erratic tertiaries—to the varying amount of denudation to which they have been subject, the form of the denuded surface, and the depth and composition of the warp, or unconformable deposit, thrown down on it. They are varied also by occasional masses of sandstone which protrude through in Alderley Edge and Delamere Forest, and by valley deposits at different heights along the lines of drainage, in which the materials of the denuded erratic tertiaries have been reconstructed. In parts of Nottinghamshire there appears to be more connexion between the soil and the rock beneath.

Coal Measures.—Mr. Charnock's* description and diagram of the soils on the coal measures of Yorkshire are virtually a reference of their formations to superficial deposits and contours. The soil is described as strong, resting on the ordinary yellow clay, which is the general subsoil of the coal districts. Where the sandstone and shale lie near the surface they produce a dry, and in some cases very productive soil. The clay with its strong soils usually occupies the valleys, and the entire rise on the lower swells, but on elevated places only extends a limited distance up the rise, where the sandstone comes through and a friable soil commences, "as though the aluminous particles had slipped or been washed down from the steeper inclinations, and formed the clay subsoil of the lower levels." As the contour becomes more marked the transitions from the friable soils of the sandstones are more remarkably noticeable. In the maps attached to the Reports on Durham and Northumberland† little relation can be traced, except in the mountainous parts, between the districts of soils into which they divide the country, and the colours of geological maps. Want of space, however, prohibits details, and we pass on to the old red sandstone.

Old red sandstone.—In the great work of Sir R. Murchison, 'The Silurian System,' will be found not only some valuable observations on the agricultural characters of the old red sandstone and the Silurian strata of the adjoining region, but some important general views respecting the relative influence of the substrata and the superficial deposits on the fertility or sterility of soils. Of the old red he says that in the high mountainous regions,

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* Journal of the Royal Agricultural Society, vol. ix. p. 289.

† Ibid., vol. viii. p. 422.

occupied by its upper formation or quartzose conglomerate and sandstones, the soil arising from their disintegration is light and sharp, and far from productive; that on the cornstone group the disintegration of their calcareous nodules, and the admixture of their component parts with the argillaceous and siliceous particles, produce the rich red argillaceous soil of Herefordshire; that the soils derived from the quartzose members of the lower sandstones are not generally so fertile as the cornstones, but that when argillaceous matter prevails they produce stripes of valuable land. "Hence, although nearly every portion of the area coloured red on the map has a red surface, the quality of the soil is as various as the many-featured strata which lie beneath."

This is the substratal view of the origin and relations of the surface soil: he adds, however, that another cause of diversity arises from the local superficial covering of gravel and silt; some tracts being wholly sterilised by the distribution of boulder stones and coarse gravel, made up of silurian trap rocks, transported from W. and N.W.; while in other parts fine gravel bears excellent crops, and the deep red silt forms plains of rich meadows. The same remarks are repeated in describing the soils resulting from the débris of the different members of the silurian system; pointing to the operations of water, by which the surface has in many instances been strewed with gravel and fine loam, and in others with coarse gravel and boulders. The finer deposits are assigned to the valleys adjacent to the great rivers; the coarser deposits chiefly to mountain sides. After discussing how far the natural vegetation of a country is dependent on its geological characters, he points out that the lithological characters of a rock are of more importance than its place in the series, and that plants affecting rocks of a particular mineral composition grow upon rocks of that composition, no matter what their geological age; and he concludes that "after all, substratal influence is constantly obliterated by over-lying detritus; and that it is therefore difficult, except on naked and stony ridges, to trace any connexion between the subsoil and the plant."

I shall conclude, then, with the proposition with which I commenced; that as geological researches are at present conducted, an essay on the agricultural geology of England and Wales must treat of it rather as it is not, and as it ought to be, than as it is. Between agriculture and geology there is an intimate connexion; but it is through the medium of the *superficial deposits*, and, when they are absent, through the *mineral* characters of the rocks. Maps which neglect both these, and exhibit little more than the areas occupied by the out-crops of certain groups of *fossils*, are nearly worthless for the purposes of agriculture.

XX.—*On the Causes of the Efficacy of Burnt Clay.* By Dr. AUGUSTUS VOELCKER, Professor of Chemistry in the Royal Agricultural College, Cirencester.

It has been, and still is, the fate of more than one good practice in agriculture to be rejected and condemned by some parties, whilst others uphold and most forcibly and confidently recommend the very same practice. In most instances in which we see advocates, equally warm and eager, defending or rejecting a disputed practice, we are generally safe in looking for some good which will ultimately be elicited from an earnest argument of the question, and we should be unwise to pass it unnoticed because we find practical men disagreeing in their opinion. A careful weighing of the question further will often show us that differences of opinion arise frequently from the disregard or non-understanding of the primary conditions under which beneficial or contrary results have been obtained. It requires but little consideration to understand why one kind of manure does not exhibit the same beneficial effects when applied to different crops, or when used on stiff, heavy, clay land, or a light sandy, or a calcareous soil. The nature of the crops, the condition of the soils, and the composition of the manuring substances with which the soil has been dressed, being known in these instances, we can trace the beneficial action of the latter with some amount of confidence at least to its cause, and are often enabled likewise to reconcile any apparent contradictions which present themselves in the application of manures.

Unfortunately, however, such cases are rare; we know, indeed, little of the rationale of many processes daily practised by the farmer, and we cannot feel surprised, therefore, to find the most opposite opinions promulgated by different persons. A wide field of inquiry here opens itself to the agricultural chemist. There are many practices which are followed by undoubtedly beneficial results in one part of the country, although they are contrary to the usages of other localities, or opposed to the ruling theories of the day; and I am convinced the scientific investigation of such practices and the scrutinizing inquiry into the valuable floating knowledge of many farmers will be followed by greater practical results, and advance scientific agriculture more rapidly than many ingenious theories have done as yet. The practical man often instinctively proceeds on truly scientific principles, and I am sure chemists, instead of denouncing a practice at once because contrary to their favourite theory, would act much wiser by endeavouring to reconcile sound practice with science.

But in order that a chemist may be successful, it is most essential that he should possess sufficient knowledge of a practical kind to enable him to investigate a chemico-agricultural question in all its bearings, or that he should avail himself of the aid which practical men will afford him.

The practice of soil-burning has long since been recommended by different persons as one of the best means of improving stiff clay land, whilst others denied the utility of soil-burning altogether. But although failures sometimes attended this practice, we are now in possession of numerous incontrovertible instances in which the application of burnt clay was followed by the happiest results. One of the most striking examples in which soil-burning proved highly economical is recorded in volume vi. page 477 of this Journal by Mr. Pusey, who very justly observes that burnt clay acts, not merely mechanically, but also as a manure (that is chemically).

The failures attending clay-burning no doubt are due in some cases to carelessness and want of skill on the part of the operator, for it is well known that in over-burning soil, instead of a friable mass, large hard lumps like brickbats are obtained, which on exposure to the atmosphere refuse to fall to powder. Soil burnt at too high a temperature, that is overburnt soil, always proves more or less inefficient. All failures, however, cannot be attributed to this cause, for it is a fact, attested by practical men well acquainted with the practice of soil-burning, that some kinds of clay after burning do not exhibit the same beneficial effects as others, or none at all when applied to the land. It becomes, therefore, an important point to determine what is the nature of those clays which prove efficacious after burning, and what are the characteristics of those clays which are unfit for burning. It is clear, however, that this question cannot be settled satisfactorily without incurring much expense, as long as we are ignorant of the true cause of the efficacy of burnt clay. In addition to other advantages, the discovery of the cause of the efficacy of burnt clay further might probably lead to improvements in the existing methods of burning clay, which might render them easier, cheaper, and more certain.

These and similar considerations, I think, will show at once the practical importance of a fundamental inquiry into the causes of the efficacy of burnt clay.

With a view of contributing something to the solution of the problem, I made some experiments last winter which have furnished me with some interesting analytical results. These, I trust, will throw some light on the rationale of clay-burning, and lead at the same time to a more extensive practice of burning heavy clay land.

In engaging in this inquiry I proposed to myself the following questions:—

1. What are the changes produced in clay upon burning?

2. How does burnt clay act in improving the soils, or, in other words, what are the causes to which the efficacy of burnt clay is due?

3. By what qualities or characteristics are clays totally unfit for burning, distinguished from those which prove most efficacious after burning?

4. Can it be determined by chemical analysis whether burning will be efficacious in rendering clay a fertilizer; or not?

5. What are the reasons of the failures attending overburning?

6. What is the reason that burnt clays improve especially root-crops?

Each of these questions I shall endeavour to answer separately.

1. *What are the changes produced in Clay upon Burning?*

When heavy clay land is burned at a proper temperature it is materially altered in its physical condition, whilst at the same time the action of the heat produces some chemical changes in the constituents of clay, which appear to me highly important. I shall consider:—

I. *The Mechanical Effects of Heat on Clay.*—The success of the operation of clay-burning depends much on the proper regulation of the temperature, and the operation itself requires, therefore, much skill and constant attention on the part of the operator; for if burnt at too high a temperature, or overburnt, clay melts or is converted into large stony masses, which do not crumble to powder under the action of the weather. Thereby not only the benefits of the heat in altering the mechanical condition of the soil are lost, but also, as I shall show presently, the benefits arising from a change in the chemical nature of burnt clay.

The mechanical effects of heat on clay are simple and easy to be understood. Heavy, stiff clay soils are impervious to water, very tenacious, and unctuous, and, for these reasons, often cold and expensive to work. Clay, when properly burnt, so that it neither melts nor becomes converted into hard, stony masses, is rendered harder to some degree, more porous, and, under the action of the weather, crumbles down to powder, without again becoming tenacious or plastic.

The application of burnt clay to heavy soils thus tends to make them more open and more friable, and consequently diminishes much the amount of labour in the subsequent working of

such soils. The mechanical effects of burnt clay, by which the physical condition of soils is altered so materially, are therefore very important, and by no means to be undervalued in an inquiry into the causes of the efficacy of burnt clay. The beneficial effects of burnt clay are ascribed by many chemists and agricultural writers entirely to its greater porosity, or rather to ammonia, which, according to their views, is absorbed from the atmosphere by burnt clay more extensively than by clay in its natural state. In order to put this theory to the test, I made the following experiments with—

1. Clay, from Huntstile, near Bridgewater, in its natural state.
2. Clay, from the same locality, moderately burnt.

Both portions were moistened with water, and exposed in glass beakers to the atmosphere for a period of two months and twelve days, without, however, renewing the evaporated water. After that period the quantity of ammonia in each sample was determined by combustion with soda-lime in the usual manner. The following are the results:—

1. Clay, from Huntstile, in its natural state, 239·15 grains, on combustion furnished 4·94 grains of bi-chloride of platinum and ammonium; or
100 parts of air-dry clay contained 0·240 per cent. of ammonia (NH_4, O).

2. Clay from Huntstile, moderately burnt, 210·15 grains, on combustion gave 0·36 of bi-chloride of platinum and ammonium; or
100 parts of air-dry clay contained 0·019 of ammonia (NH_4, O).

The clay when unburnt, it will be observed, furnished a much larger quantity of ammonia than the same clay after moderate calcination. We must, however, not conclude that unburnt clay possesses a greater power of absorbing ammonia from the atmosphere, for the ammonia obtained in the analysis is partly the result of the decomposition of nitrogenised organic matters which were present in the clay, and which were destroyed on burning.

At all events, the above analyses show that unburnt clay contains ammonia, or the elements from which ammonia is formed, in larger quantities than burnt clay. The quantity of ammonia absorbed by burnt clay besides is so inconsiderable that it cannot be justly regarded as likely to influence in a sensible degree the fertility of the soil to which burnt clay is applied. For that reason I cannot attach much value to the ammonia theory.

Sprengel ascribes the beneficial action of burnt clay to ammonia, which he says is formed in burnt clay under the influence of protoxide of iron by the decomposition of water and the nitrogen of the atmosphere. Burnt clay, he thinks, will lose its effects as soon as the protoxide of iron is changed into peroxide, because then the further decomposition of the water and the

formation of ammonia cease. I have examined burnt clays which contained no protoxide of iron at all, and which, nevertheless, were found most efficacious as a manure. This fact alone contradicts Sprengel's theory; but in order to learn if in clay, containing much protoxide of iron, more ammonia is formed than is absorbed by the same clay from the atmosphere, I made the following experiments:—

A portion of clay, from Huntstile, was moderately burnt in a closed crucible, after having been previously mixed with 1 per cent. of charcoal powder. The charcoal powder was mixed with the clay for the purpose of reducing the peroxide of iron in the clay to protoxide.

a. One-half of the clay thus treated was exposed for two months and fourteen days to a dry atmosphere, in a dry state:—

182·81 grains gave 0·28 grains of bichloride of platinum and ammonium; or,
100 parts gave 0·17 per cent. of ammonia.

b. The other half was thoroughly moistened with water, and exposed for the same length of time to the atmosphere:—

212·11 grains gave 0·33 grains of bichloride of platinum and ammonium; or,
100 parts gave 0·18 per cent. of ammonia.

These quantities of ammonia are nearly identical. Ammonia, accordingly, is not formed, as Sprengel supposes, by the decomposition of water under the influence of protoxide of iron and the atmosphere, in a larger quantity than is absorbed by dry clay from the atmosphere.

Thus, under no circumstances, do we find ammonia in burnt clay in so large a quantity as to justify us in regarding it as the chief cause of efficacy in burnt clay. The effects of burnt clay cannot be explained by the absorption of ammonia only, nor, indeed, by the mechanical changes which burnt clay has undergone after burning. In a great measure, the efficacy of burnt clay is due to the chemical changes to which the constituents of clays are subject in burning.

I shall therefore consider:—

II. *The Chemical Effects of Heat on Clay.*—In an excellent paper on the effects of burnt clay, Professor Johnston expresses the opinion that the mechanical effects of burning upon clay are insufficient to explain the efficacy of burnt clay; and proves experimentally that clay, upon burning, is subject to chemical changes, which are of such a kind as to render the constituents of clay more soluble. To these chemical changes the learned Professor attaches even more importance than to the mechanical alteration of the condition of the soil.

By my own experiments, I am enabled to confirm Johnston's observations respecting the greater solubility of burnt clay, and the diminution of this solubility in over-burnt clay. I have found further the important fact that, in burning clay properly, a *large amount of potash is liberated* from the constituents of the clay and rendered soluble which existed before burning in the clay in an insoluble state. I am indebted for the material with which my experiments were made to Sir Thomas Tancred, who procured for me some clay of the new red sandstone formation from the farm of Huntstile, near Bridgewater, tenanted by Mr. Thomas Danger.

The nature of the chemical changes which may be supposed to affect the action of burnt clay on the land to which it is applied, was examined by four distinct analyses:—

No. I. Clay-soil in its natural state.

No. II. A quantity of the same clay-soil was exposed to a *dull* red heat in a *closed* platinum crucible, and kept at that temperature for half an hour. The clay, after burning, had a dark-grey colour.

No. III. Another portion of the same clay-soil was exposed to a red heat for half an hour in an open crucible. The contents of the crucible were frequently stirred with a platinum wire, in order to effect the complete combustion of the organic matters, and to secure the perfect oxidation of any protoxide of iron which was present in the clay. After burning, the colour of this portion of the clay was red, rather brighter than the natural colour of the soil.

No. IV. A fourth portion of the same clay-soil was exposed for about three hours to a full red heat in an open crucible.

As water, saturated with carbonic acid, produces the same effects on the constituents of clay as dilute acid, and acts only slower, I preferred to apply dilute muriatic acid, instead of water charged with carbonic acid, in order to test the solubility of the above four samples of clay. Accordingly, separate quantities of Nos. I., II., III., and IV. were boiled for half an hour in four ounces of dilute acid, containing one-tenth of its bulk of hydrochloric acid. The insoluble part of the clay was collected on a filter, and washed with distilled water until nothing more was dissolved.

In the soluble part of Nos. I., II., III., and IV., the following substances were determined quantitatively: soluble silica, oxide of iron and alumina, carbonate of lime, potash, soda, and phosphoric acid.

In No. IV. phosphoric acid was not determined.

The following Table exhibits the results of these several analyses:—

Clay from Huntstile, near Bridgewater.	No. I.	No. II.	No. III.	No. IV.
Water, driven off at 212° F.	5·539	9·160	9·200	9·300
Organic matter and water of combination	3·621			
Insoluble matter (in dilute hydrochloric acid)	84·100	80·260	81·845	85·309
Soluble matter, consisting of—				
Soluble silica	1·450	1·380	1·580	1·150
Oxides of iron and alumina	3·070	8·245	6·092	2·970
Carbonate of lime	·740	·420	·550	·188
Potash	·269	·941	·512	·544
Soda	·220	·336	·314	·104
Phosphoric acid	·380	·165	·128	undetermined
Chlorine and sulphuric acid	traces	traces	traces	traces
Magnesia (not determined)	..	..	..	..
	99·389	100·907	100·221	99·565
On combustion with soda-lime, ammonia ($N\ H_4,\ O$) produced in	0·240	0·019 0·017 0·018	..	0·008

These analytical results give rise to the following suggestions :—

1. That, after burning, this clay has become much more soluble than clay in its natural state.

2. They not only teach generally that clay becomes more soluble in burning, but that the temperature to which it is exposed mainly regulates the solubility of the clay. A proper temperature for burning clay is indeed a condition in the process on which the success of the operation chiefly depends. We see, from the preceding tabulated results, that clay, in 100 parts in its natural state, furnishes only 6·74 grains of soluble inorganic matter, leaving 84·100 insoluble behind; whilst the same clay, burnt at a temperature and under circumstances under which the organic matter was not altogether destroyed, left 80·260 of insoluble matters. An increase of the temperature, sufficiently high to burn off the small amount of organic matter which enters into the composition of this clay, had the effect of reducing the solubility of its constituents to about 1½ per cent.; and a more protracted exposure to a still higher temperature had the effect of a further reduction of its solubility to such an extent that this over-burnt clay became less soluble than the same clay in its natural state:—

	Proportions of Soluble Inorganic Matters.	Proportions of Insoluble Inorganic Matters.
Clay, No. I. (unburnt)	6·740	84·100
,, No. II. (slightly burnt)	10·580	80·260
,, No. III. (burnt stronger than II.)	8·955	81·845
,, No. IV. (over burnt)	5·391	85·309

3. The above analyses distinctly prove the important fact, to which I would invite particular attention, that the *alkalies*, more particularly *potash*, are rendered *soluble* to a considerable extent in the process of burning.

The temperature to which the clay has been exposed here regulates the proportion of potash, rendered soluble in dilute hydrochloric acid, in a remarkable manner.

In the natural clay, only 0·269 per cent. of potash were soluble; whereas, in clay burnt at a moderate heat, and under circumstances resembling those under which clay is burnt in the field, the quantity of soluble potash amounted to more than three times the former quantity. In Clay, No. II., the higher temperature to which it was exposed caused a diminution in the proportion of soluble potash; and in No. III. nearly the same quantity of potash as in No. IV. was obtained:—

	Proportions of Soluble Potash.
Clay, No. I. (actual state)	0·269
,, No. II. (slightly burnt)	0·941
,, No. III. (stronger burnt)	0·512
,, No. IV. (over burnt)	0·544

The actual quantities of soda rendered more soluble in burning are trifling, but still sufficiently large to confirm the fact that soda is rendered more soluble in burning. The higher temperature applied in burning Nos. III. and IV. likewise was attended with a slight diminution of soluble soda:—

	Proportions of Soluble Soda.
Clay, No. I.	0·220
,, No. II.	0·336
,, No. III.	0·314
,, No. IV.	0·104

4. A reference to the tabulated analytical results further shows that the relative quantities of lime in the soluble portion of each vary considerably:—

	Proportion of Soluble Lime, calculated as Carbonate.
Clay, No. I.	0·740
,, No. II.	0·420
,, No. III.	0·550
,, No. IV.	0·188

The three latter quantities are marked down in the analyses as carbonate of lime, for the sake of comparison with No. I., in which the lime really existed as carbonate of lime; but as not the slightest effervescence took place on dissolving the burnt

clay in dilute muriatic acid, it is clear that the lime did not exist in a state of carbonate. The lime must have existed in Nos. II., III., and IV. as caustic lime, or in a state of silicate.

The excess in analyses Nos. II., III., and IV. is partly due to this inaccuracy of stating the results, partly to the fact that silicate of protoxide of iron in burning becomes decomposed. The protoxide of iron is rendered soluble in dilute muriatic acid, but in the analyses it is obtained and calculated as peroxide; hence we find the largest excess in No. II., in which most iron has become soluble in dilute acid after burning.

The following considerations, which at the same time explain the mode in which potash is liberated from the constituents of clay and rendered soluble, induce me to think that the lime in Nos. II., III., and IV. existed in a state of silicate. The usual method of determining the quantity of potash and soda in insoluble silicates consists in fusing the finely-powdered substance with an excess of carbonate of baryta. In this process potash and soda are rendered soluble in the following manner: the baryta combines with the silica, originally present in combination with potash and soda; silicate of baryta is formed, and the alkalies potash and soda uniting with the carbonic acid of the carbonate of baryta are rendered soluble.

Lime, which in its chemical relation is closely allied to baryta, acts precisely in the same manner on insoluble silicates of potash and soda. If clay originally contains carbonate of lime, it will act at an elevated temperature on the insoluble silicates of potash and soda, present in many clays in the form of fragments of felspar or mica, and by duple decomposition it will give rise to the production of silicate of lime and carbonate of potash. Silica enters into combination with lime in different proportions; some of these combinations are soluble in dilute acids, most of them are insoluble. Instead of carbonate of lime and insoluble silicate of potash, we thus find in burnt clay a larger proportion of soluble potash and silicate of lime, which is partly insoluble in dilute acids. The diminution of the quantity of lime, and the more abundant proportion of potash in the soluble part of burnt clay, thus find a ready explanation. Much, however, as indicated by the practical observations and the above analytical results, depends on the proper regulation of the temperature.

2. *How does Burnt Clay act in improving the Soils; or, in other words, what are the causes of the efficacy of Burnt Clay?*

The answer to this question will become much more intelligible, after we shall have considered briefly the origin and com-

position of agricultural clays, and pointed out those substances in clays on which their fertilizing properties chiefly depend.

Clays generally result from the disintegration and degradation of granitic and felspathic rocks. Felspar, a mineral composed of silicate of potash or soda and silicate of alumina, exposed for a long time to the united action of the atmosphere and water, suffers a gradual decomposition, and falls altogether to powder. Silicate of potash, a soluble salt, is worked out by the rain falling on the decomposed rock, and converted in its turn, by the carbonic acid of the atmosphere, into carbonate of potash and silica, which remains behind in a gelatinous or soluble state with insoluble silicate of alumina, the chief constituent of clays. The analyses of different samples of agricultural clays exhibit many differences in their composition, and show that agricultural clays are never pure silicate of alumina, but mixtures of pure clay (silicate of alumina) with more or less sand, undecomposed fragments of felspar, mica, granite, and other minerals, carbonate of lime, magnesia, free or uncombined alumina, oxide of iron, soluble silicate of potash, traces of phosphoric and sulphuric acid and chlorine. In some clays lime occurs in so large quantities, that on this account they cannot be used for the making of tiles. Of such a kind is Bradford clay, from the neighbourhood of Cirencester, in which I have found no less than 19·92 per cent. of carbonate of lime. In others little lime, but considerable quantities of free alumina and oxide of iron are found. To this kind of clays belongs an agricultural clay, the analysis of which I subjoin, in order to show its complex composition:—

Analysis of Clay from Huntstile Farm, near Bridgewater.

Water of combination, and a little organic matter	3·38
Insoluble siliceous matter (fine clay)	54·89
Finely-divided silica (soluble in dilute caustic potash)	17·94
Oxides of iron	8·82
Alumina	6·67
Lime	1·44
Magnesia	0·92
Phosphoric acid	0·51
Potash	1·48
Soda	1·08
Traces of sulphuric acid and chlorine, carbonic acid, and loss	2·87
	100·00

On these foreign admixtures, which all agricultural clays contain, and the state of division of the sand and other constituents, the plasticity, tenacity, porosity, and other physical characters depend. In an examination of an agricultural clay, therefore, not merely its ultimate chemical composition should be ascertained, but likewise

its mechanical condition. This has been done with a sample of plastic clay from Coldash Common, near Newbury, which I owe to the kindness of Mr. Robert Brown, of Cirencester. By washing carefully clay with water, and collecting the deposit which subsides from the muddy liquid at different intervals, a tolerably good idea of the state of division of the clay can be formed:—

Analysis of Plastic Clay from Coldash Common, near Newbury, Berkshire.

1. Mechanical Examination.

100 parts of this clay contain—

Fine quartz sand, deposited after five minutes	54·64
Clay, with a little very fine sand, deposited after ten minutes.	10·52
Fine clay, deposited after fifteen minutes	2·57
Finest clay, remaining suspended in water after the lapse of a quarter of an hour	32·27
	100·00

2. Chemical Examination.

a. *General Analysis.*

Water of combination, and a little organic matter . . .	8·698
Sand	54·640
Pure clay	25·462
Oxides of iron and alumina, lime and other substances, soluble in acids	11·200
	100·000

b. *Detailed Analysis.*

Water of combination, with a little organic matter . .		8·698
Silica		73·736
Soluble oxides of iron and alumina	5·031	12·138
Insoluble	7·107	
Lime		2·980
Magnesia		0·047
Potash		2·077
Soda		0·525
Chlorine		a trace
		100·201

Not only the mechanical state of division, and the relative proportions of the foreign admixtures which are found in agricultural clays, influence their characters, but also the state of combination in which the constituents of such clays occur, materially alters their properties. In the subjoined analyses of three samples of clays from Dumbelton, Gloucestershire, made in my laboratory, care has been taken to ascertain the state of combination in which the constituents of these clays are likely to occur:—

Clays from Dumbelton.	No. I.	No. II.	No. III.
Water of combination and organic matter	7·69	6·62	6·68
Oxides of iron	8·24	7·33	8·63
Alumina, soluble in acids	8·04	10·62	9·25
Alumina, in a state of silicate	10·04	7·06	9·66
Lime, carbonate of	1·12	0·70	0·19
Lime, in a state of insoluble silicate	0·44	0·54	0·24
Magnesia, soluble in acids	0·62	0·12	0·56
Magnesia, in a state of insoluble silicate	0·34	0·39	0·34
Potash and soda, soluble in acids	0·73	1·04	1·13
Potash and soda, in a state of insoluble silicate	0·94	2·70	1·82
Silica (soluble in acids)	0·09	0·06	0·08
Silica (insoluble in acids)	61·71	62·82	61·42
	100·00	100·00	100·00

Having given a brief outline of the origin and composition of agricultural clays, let us see, in the next place, on which of their constituents their fertilizing powers depend.

In a chemical point of view, silicate of alumina (pure clay) does not contribute in itself to the direct nutrition of plants, as it is not found in the ashes of cultivated plants. We must look, therefore, for the direct fertilizers of clays amongst the accessary or foreign ingredients of agricultural clays. Of these lime, magnesia, sulphuric acid, silica, and chlorine, are, indeed, essential to the growth of plants; but as these substances are found in most soils, or can be supplied at a cheap rate when deficient, the chief value of an agricultural clay depends on the proportion of phosphoric acid and potash and soda, which it contains. Potash, in particular, is an essential element in all ashes of plants, and acts as most powerful manure. The chief source of potash in ordinary soils is the clay, which enters into the composition of almost all soils. Clay, we have seen, is in many cases derived from felspar, a duple silicate of alumina and silicate of potash, and frequently contains some undecomposed fragments of felspar or similar minerals; from which, under the action of the weather, potash is liberated and rendered available to plants. The large amount of felspar and similarly composed minerals, in some clays, thus furnishes an almost inexhaustible supply, from which plants may derive their potash. Plants, however, can only avail themselves of the soluble potash which exists in clays, and not of the potash which occurs in them in the form of felspar. But as the soluble potash in clay soil sooner or later will be exhausted by the removal of the crops grown upon it, the soil gradually becomes more and more sterile, and at last refuses to grow any remunerative crop. The natural fertility of exhausted soil is then restored again by the process of fallowing. By that process a fresh portion of the soil, not hitherto exposed to the action of the

atmosphere, is brought up; and, amongst other changes, the undecomposed fragments of felspar are forced, by the combined action of air and water, to yield their potash and soda, which are the indispensable requisites of a healthy vegetation.

In an age of railway and steam enterprise and telegraphic despatch, agriculture is forced to progress, and, in consequence of this, fallowing must necessarily yield to some more extensive and expeditious means of gaining the same advantages. Soil-burning is one of these means. The above-mentioned analyses have taught me that, in burning clay, a large proportion of potash, which existed before in an insoluble state, is liberated and rendered available for immediate use by plants. In burning clay then similar changes are effected in a few days, which in bare-fallowing are produced in so many months. To this *liberated potash* I am inclined to ascribe the *chief efficacy* of burnt clay, without, however, considering the mechanical changes clay undergoes in burning as unimportant.

The fact that felspar is more readily decomposed after having been moderately calcined is not a new one, Professor Fuchs, of Munich, having shown clearly that this is the case not only with felspar, but also with other minerals, into the composition of which silicate of potash enters. Fully in accordance with this fact is the practical observation of Professor Lampadius, who found, by a series of field experiments, that moderately calcined gneiss, granite, certain kinds of porphyry and trap rocks, all of which contain silicate of potash in a similar manner as burnt clay, promote the luxuriant growth of many plants in a remarkable manner.

Phosphoric acid, the only other valuable constituent of agricultural clays, is not rendered more soluble by burning, but rather the contrary; the efficacy of burnt clay, therefore, cannot be due to phosphoric acid.

I have shown above in what manner lime appears to me instrumental in liberating the potash of clays. If this explanation of the action of lime on silicate of potash is true, we can easily conceive how the addition of lime to clay, originally poor in this element, will increase the amount of soluble potash and soda. I would, therefore, suggest the application of quick-lime to newly burnt clay land, or the mixing of clay with lime before burning, as likely to be attended with most beneficial effects. The explanation of the action of lime on clay, and the suggestion I have thrown out, are supported by an observation of Professor Fuchs, of Munich, to which particular interest attaches. This distinguished man found that when felspar is moderately burnt, and in a powdered state is boiled with quick-lime and water for a short time, or even digested in the cold with quick-lime and water for a longer period, so large a proportion of potash is liberated from

the constituents of felspar, that on these grounds he recommended a process of extracting and manufacturing potash on a large scale from felspar. He has shown that, under these circumstances, insoluble silicate of lime and soluble carbonate of potash are formed.

3. *By what qualities or characteristics are clays totally unfit for burning distinguished from those which prove most efficacious after burning?*

Pure clays, such as pipe and porcelain clay, consist almost entirely of silica and alumina; and as silicate of alumina does not itself serve as direct food to plants, they are found to be sterile in their natural state, and will remain so after burning. We have seen that the accessary constituents of clays furnish the materials from which plants derive their inorganic food, and that potash is the most valuable constituent of clays. The proportion of potash in clays varies considerably; whilst some contain from 2 to 4 per cent. of potash, others contain but mere traces. Now, if it be true what has been advanced with respect to the causes of the efficacy of burnt clay, I have no hesitation in pronouncing all clays which contain no potash at all, or mere traces, as totally unfit for burning. Experience, I think, will prove that all clays which nearest resemble in composition pipe and porcelain clays, and are naturally very infertile, will not in the least be improved by burning. On the other hand, the more undecomposed potash in the shape of felspar or any other mineral a clay contains, the more useful it will be found after burning. In support of the theory I have embraced, with respect to the efficacy of burnt clay, it may be mentioned that I have determined the whole amount of alkalies which the clay from Huntstile farm contained in any form. The greater part of potash and soda in this clay is present in the state of insoluble silicate; and as I find no less than 4·726 per cent. of potash and ·88 per cent. of soda, I have no hesitation in suggesting that this clay is most likely to prove very efficacious after burning. With this theoretical speculation agrees well the fact mentioned by Mr. Danger, the tenant of Huntstile farm, that by burning this clay the land is very much improved. Mr. Danger says:—" Of course I can only speak to the fact. A soil, which I have found *quite sterile,* on which this process has been used, became *totally changed.*"

4. *Can it be determined by Chemical Analysis, whether burning will be efficacious in rendering Clay a fertiliser; or not?*

From the preceding remarks it follows that the fertilizing effects of clay mainly depend on the proportion of potash which it contains; and as any good analytical chemist may determine the

exact quantity of potash which may be extracted from a clay, we possess the means of deciding at once whether a clay is likely to be efficacious or not. The advantages which result from a previous analytical examination become most conspicuous when we consider that the trifling expense for analysis will guard the farmers against failures and loss attending the investment of much money and labour in burning soils which cannot be rendered more fertile by this operation. Chemistry, in this manner, I have no doubt, will be found to confer material benefits on those who avail themselves of its aid.

5. *What are the reasons of the failures attending overburning?*

Professor Johnston has already shown that, in overburning the constituents of clay, they are rendered less soluble than when properly burnt. My own experiments fully confirm the Professor's observations. Overburnt clay, I have found further, does not absorb so much ammonia from the atmosphere as properly burnt clay, which is easily explained by the diminished porosity, and consequently diminished absorptive power of such clays.

A portion of overburnt clay from Huntstile was exposed to the atmosphere, moistened with water, for two months and thirteen days. The amount of ammonia absorbed by the clay was then determined by combustion with soda-lime. 219 grains of air-dry clay gave 0·155 grains of bichloride of platinum and ammonium, or 100 parts furnished only 0·008 per cent. of ammonia. Moderately burnt clay will absorb double the quantity of ammonia from the atmosphere which will be absorbed by overburnt clay under precisely the same circumstances. The causes of the failures attending overburning I am, therefore, inclined to ascribe —1. To the mechanical changes clay undergoes in burning. 2. To the chemical changes which render such clays less soluble. 3. To the diminished power of absorbing ammonia from the atmosphere.

6. *What is the reason that Burnt Clays improve especially Root-crops?*

All root-crops—such as turnips, carrots, swedes, mangolds, potatoes, &c.—require much potash as a necessary article of food. The ashes of these plants contain about half their weight of potash. Mr. Woodward's observation that root-crops are particularly benefited by burnt clay thus receives an easy explanation from the mode of its action, which I have endeavoured to explain in the preceding pages.

In conclusion, I may be allowed to recapitulate briefly the principal and most practical facts which the foregoing investigation has taught me:—

1. The mechanical changes produced on clay upon burning, which by no means are *unimportant,* nevertheless do not sufficiently explain the fertilizing effects of burnt clay.

2. These are dependent on the chemical as well as on the mechanical changes both produced upon burning clay.

3. The fertilizing effects of burnt clay are mainly dependent on the larger amount of potash which is liberated from the insoluble silicates of the clay in the process of burning.

4. Burnt clay contains more soluble potash than the same clay unburnt.

5. Clay after burning becomes more soluble in dilute acids.

6. The temperature used in burning clay regulates the solubility of clay; too intense a heat renders clay again less soluble.

7. A temperature whereby the organic matter in clay soils is merely charred, but not altogether destroyed, should be employed in burning clay in the field.

8. Properly burnt clay furnishes a larger proportion of soluble potash and soda than clay burnt at too high a temperature.

9. In burning clay similar effects are produced as in bare-fallow.

10. Clays, originally containing a large proportion of undecomposed silicates of potash and soda, are best suited for burning.

11. On the contrary, those resembling in composition pure pipe or porcelain clays, and all those which contain mere traces of undecomposed alkaline silicates, are unfit for burning.

12. It is desirable that clay which is intended to be burnt should contain lime.

13. The application of quick-lime to newly-burnt clay land, or the mixing of clay with lime before burning, is likely to be attended with much benefit.

14. Overburnt clay does not absorb so much ammonia from the atmosphere as properly burnt clay.

15. The causes of the failures attending overburning are due:—

   1. To the mechanical changes which clay undergoes in overburning, whereby it is rendered hard, like stone.
   2. To the chemical changes, whereby the constituents of clay are rendered less soluble.
   3. To the diminished porosity, and consequently reduced absorptive power, of such clays.

16. Burnt clay improves especially turnips, carrots, potatoes, and other green crops, because it supplies potash, which these crops largely require, more abundantly and more readily than unburnt clay.

XXI.—*On Mismanagement of Farm-Horses.* By Finlay Dun, jun., V. S., Lecturer on Materia Medica, &c., at the Edinburgh Veterinary College.

Prize Report.

There are certain conditions which must be fulfilled by man, in order to preserve the domesticated animals under his charge in proper health and vigour. These conditions consist chiefly in furnishing them with a sufficiency of good food and pure air, and with efficient shelter from the inclemency of the weather. The proper fulfilment of these conditions constitutes what we understand by good management, whilst the neglect or violation of them constitutes mismanagement.

It is obvious that our definition of mismanagement applies to every error in the management of all the domesticated animals; but as the present Report is restricted, under several subdivisions, to the "diseases arising from mismanagement of farm-horses," we have to consider the subject in regard to them alone, and under the following prescribed heads:—

1. Insufficient or improper food.
2. Overwork.
3. Insufficient shelter.
4. Neglect of incipient disease.
5. Want of medical skill in professional attendants.

The diseases induced by bad management of farm-horses are numerous and occasionally severe. They may supervene immediately after an error in management has been committed, but more frequently spring from weakness and susceptibility to disease, produced by continued neglect or error. Thus, a single instance of abstinence from food, or exposure to rain or to cold, seldom produces, in a healthy animal, any permanent evil; but when such instances become frequent, they soon begin to develop their injurious consequences. It is, therefore, by no means a fair criterion of any system of management to say that it must be good because under its operation disease is not speedily perceptible, for among the lower animals, as well as in man, mismanagement may frequently be long continued before its bad effects become at all apparent. Thus, insufficient food, overwork, and insufficient shelter, require a considerable time before they produce even their earliest effects; but in proportion as these effects are slow and imperceptible in their development, they are the more to be dreaded, on account of the ravages they may make before being detected or arrested.

Any single cause of disease is greatly strengthened by the co-operation of other causes. For example, deficient ventilation, or want of cleanliness, materially aggravates the evils resulting

from hunger, overwork, or exposure to wet or cold; and again, overwork and want of shelter are much more severely felt by ill-fed than by well-fed animals. Farther, the evil effects of mismanagement are modified by conditions inherent in the animals themselves. Those of strong and vigorous constitution, of hardy breed, or mature years, are less affected by errors in management than those of delicate frame, of highly artificial breed, or of tender years.

But although in favourable circumstances, and in certain animals, some sorts of mismanagement may appear, for a time, to be without effect, still they sooner or later produce evident injury, disease, and loss, and thus afford the strongest possible evidence of both the sanitary and pecuniary advantages of good management. Indeed, there is probably no method by which the advantages of good management can be so clearly shown as by noting the evils of mismanagement. Causes of disease, previously unnoticed or disregarded, are thus exposed to view, and their injurious influences ascertained; attention is also directed to the *preventive* treatment of disease, which is always more certain and satisfactory than the *remedial* treatment, besides being of higher practical value, since it affects numbers rather than individuals, and, when properly studied, leads to the adoption of extensive sanitary improvements.

But without further preface we proceed to the consideration of the first head of the present Report.

1. *Insufficient or improper Food.*—The subject of dietetics is so extensive, and the topics it embraces so closely connected with each other, that it is somewhat difficult to consider the questions of insufficient and improper food in a detailed and distinct manner, without making some preliminary observations on food in general. We shall, therefore, consider the subject of insufficient and improper food under the following heads:—(*a*) The uses of food and the general effects of starvation; (*b*) the quantity of food requisite for farm-horses; (*c*) the division of food into two great classes, and the proportion in which these should exist in the diet of the horse; (*d*) the injurious effects of insufficient food (that is, food defective either in quantity or nutritiveness), and its influence in developing disease; (*e*) the evils of too long intervals between the times of feeding; and (*f*) the diseases induced by improper food, by excessive quantity and unsuitable quality of food.

(*a*) Every tissue of every animal is constantly undergoing change and decay. Every action, physical or mental, occasions a waste of the structure immediately concerned in the production of that action. Every act of the mind causes a consumption of the tissues of the brain, and every contraction of a muscle renders useless and

effete some of the particles of that muscle. This waste produces a constantly recurring demand for new material. At definite intervals this demand attracts attention by exciting the sensation of appetite or hunger; and this sensation is removed and the demand satisfied when new material or food is introduced into the body in sufficient quantity and of suitable quality to repair this waste. In such circumstances the demand and the supply are justly balanced. When, however, the supply exceeds the demand, the animal increases in size and in weight. When, on the other hand, the demand exceeds the supply, when the amount of waste or effete matter is greater than that which the animal can assimilate from its food, the diet is insufficient, and loss of weight and starvation of some of the structures of the body soon occur. But a system of diet may vary much in the degree of its insufficiency. It may be so greatly defective as speedily to cause death, or so little defective that even after some weeks its effects are scarcely apparent, while between these two extremes the symptoms and effects of the error are of all degrees of intensity.

When the animal is entirely deprived of food, the weight of the body speedily decreases. Those tissues suffer first which are least essential to life: the fat disappears; by and by the muscles shrink and waste; then the bones lose weight; and last of all, the blood becomes so small in quantity and so impoverished in quality that there is not even sufficient nutriment for the brain and other parts of the nervous system, and death shortly follows. The time that animals survive total abstinence from food is much modified by circumstances. When in good condition and arrived at maturity, they live longer than when lean and not fully grown. When supplied with abundance of good water they also live longer than when deprived of food and water. Thus man, when deprived altogether both of food and water, dies in eight or nine days; but with plenty of pure fresh water, life is often sustained for nearly three times as long. In similar circumstances a horse will live about the same time as a man. Such extreme cases of deprivation are, however, exceedingly rare, but derive great interest from exhibiting in a short space of time, and in the greatest intensity, evils which a less insufficient system of diet develops only after a great length of time, and in a much less aggravated form. The effects, however, though differing widely in degree, are essentially the same in kind; and all the symptoms of insufficient food, and the diseases to which it tends, depend upon the fact that the waste exceeds the supply.

(*b*) It may not be out of place to notice briefly the *quantity* of food requisite to maintain farm-horses in good health and condition. This is modified by various circumstances, but especially by the nature and amount of the work they perform. An allowance,

suitable during the spring months, and when the work is pretty severe, may consist daily of the following proportions of oats, hay, and roots, viz. from 10 to 13 lbs. of oats, at 40 lbs. weight per bushel; 14 lbs. of hay, and about 40 lbs. of steamed turnips or potatoes. The oats should be bruised, and are most economically given at two different times—one half in the morning and the other half about noon. It contributes much to the condition of horses to give them a small quantity of beans along with, or instead of, a part of their oats. Hay and other fodder should always be given cut; for, by such preparation, it is more easily masticated and digested, and the animal is thus allowed more time for rest. In some parts of the country cut straw is substituted for hay, especially during autumn and the early part of the winter, but such a substitution diminishes the nutritiveness of the diet. The boiled or steamed food is useful for keeping the bowels in good order. It should be mixed with chaff, chopped straw, or meal-seeds, and with a handful of common salt; and part should be given when the horse returns from work in the evening, and the remainder an hour or two after.

(*c*) Food, besides being insufficient in absolute quantity, is often insufficient from containing an inadequate supply of nutritive materials. To be nutritive, food must be capable of forming healthy blood, and of building up the various animal tissues. All varieties of food have been divided by Liebig into *two* great classes —*the plastic elements of nutrition*, and *the elements of respiration*. The former class includes substances such as animal and vegetable fibrine, albumen, and casein—the latter, substances such as starch, gum, sugar, and fat. All articles of the former class contain nitrogen or azote, and are hence termed nitrogenous or azotized substances. On the other hand, the articles of the latter class contain no nitrogen, but are rich in carbon, which is often united with the elements of water; and hence they are termed non-nitrogenous, non-azotized, carboniferous, or hydrocarbons. Substances of these two different classes are applied in the animal body to very different purposes. The azotized principles are employed for repairing the waste, and adding to the bulk of the muscles and all the more highly organized tissues—they are the flesh-producing principles. The non-azotized articles of food are consumed in all parts of the body to support the animal heat; they are burned, or enter into chemical union with the oxygen which enters the blood at every inspiration—they cannot form blood or flesh.

Every natural system of diet, and every system adequate to support life, contains representatives of each of these two classes. In milk, the azotized principles are represented by the casein, and the non-azotized by the saccharine and oily matters; and so also

in the food of adults substances of each class are naturally mingled. Animals restricted exclusively to azotized food soon become unhealthy, and die from the want of fuel to support the animal heat; while, on the other hand, those fed on non-azotized food, as pure starch, gum, or sugar, die in a very short space of time; dogs, for instance, in about thirty days. In such cases death occurs in about the same time, is preceded by very similar symptoms, and produced much in the same way as when no food whatever is given. After confining an animal for some days to such food, the nutrition of the body is so disturbed, and the powers of life so depressed, that death speedily occurs; nor after a certain time will the substitution of a sufficient diet be of any avail.

The injurious consequences of *too highly azotized food* are seldom or never seen amongst farm-horses, their food rarely containing, for any length of time, an excessive proportion of azotized matters. The injurious effects of an inadequate proportion of these are, however, of frequent occurrence; and food is more often insufficient in this respect than from being defective in absolute bulk. The proportion in which the azotized and non-azotized elements should exist in the food of horses employed for ordinary farm-work should be one of the former to five or six of the latter. This proportion of nitrogenous principles is somewhat less than that necessary for man, and somewhat greater than is generally present in the food either of cattle or sheep. It will, however, be found to be the proportion in which these two sorts of alimentary principles are present in all well-ordered dietaries for the horse. In some circumstances it may, without detriment, be slightly altered. Thus, horses whose work is light will maintain their condition on a somewhat less proportion of nitrogenous principles than that above stated; while those, on the other hand, whose labour is severe and long continued, require a still larger allowance. Young animals, from the rapid growth of all their tissues, also require, for healthy existence, a larger proportion of nitrogenous principles than adults; and we accordingly find these principles forming nearly one half of the solid ingredients of all sorts of milk.

(*d*) With reference to man, as well as to the domesticated animals, errors of diet are common, and often attended by serious evil consequences. Numerous facts and statistics, published during the last few years, show that the continuance of a deficient or improper diet inevitably produces sickness and mortality, and this has been especially observed among the lower classes of the community. The recorded rates of mortality in years of famine are always far above the average, and always bear a very close relation to the price and abundance of food, and especially of wheat.*

* Statistical Journal for June, 1846—Paper by Mr. Farr on the Influence of

Such statistics are of great value, as showing the influence of insufficient food on a very large scale. The history of the Royal Navy, prior to the end of last century, also furnishes corroborative facts on this subject. Until then scurvy, fevers, dysentery, and sloughing ulcers produced incalculable suffering and mortality, and, in the words of Captain Cook, "tremendous calamities" and "depopulation of fleets." By the introduction of a sufficient and well-selected diet the crews of our navy have been almost entirely freed of these destructive diseases. "In 1797," says the official report, "the victualling was changed, greatly improved, and strictly regulated; and consequent immediately to the change the health of the seamen improved strikingly: scurvy, typhoid fever, dysentery, and ulcer, which up to the period of the change had produced great havoc, became comparatively rare in occurrence and light in impression."*

From the reports of prisons, workhouses, and other public institutions, we might adduce many other striking instances of disease and death resulting from ill-regulated diets. What has been already mentioned will, however, suffice to show that an abundance of good food is essential to the health of man; and if this is true in regard to man, few will dispute that a sufficiency of food is equally essential to the health and well-being of the horse. Indeed, from his nature and the laborious services exacted from him, the injurious influences of insufficient food are as speedily and certainly developed in him as in man, and far more speedily and certainly than either in cattle or sheep.

By *insufficient* food we understand food insufficient either as to quantity or as to nutritiveness; and in the following pages we shall use the term in this twofold sense. It will, however, be obvious from the preceding remarks that these two forms of insufficient food produce similar effects, and that both operate injuriously by reducing the strength and general vigour of the system. Under either system of starvation, horses become lean and miserable looking; their bellies flat, and their quarters thin and angular; their skins adherent to their ribs, and infested with lice and other vermin; and their hair rough and coarse. Their strength and spirit also fail; they are unfit even for moderate exercise, and are dull and listless. These are the consequences of insufficient food with which, on account of their comparatively frequent occurrence, we are most familiar. When, however, the defective feeding is still more excessive, or of longer continuation,

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Scarcities and High Prices on the Mortality of the People of England, vol. ix. p. 163 *et seq.*; Fifth Report of the Registrar-General, or an abstract of the same in Combe's 'Dietetics,' 9th edition, p. 104.

* Statistical Report of the Health of the Navy for the years 1830–36 inclusive, p. xiii.

or when its injurious consequences are aggravated by other errors in management, it leads to still greater evils, some of which may be here enumerated. The gradual removal of the fat and shrinking of the muscles produce extreme emaciation; the digestive system loses its tone; and diarrhœa, and even dysentery, appear, which rapidly reduce the fast-failing strength. The blood is thin and watery, and passes through the walls of its vessels, causing serous swellings in various of the dependent parts of the body, as in the limbs and about the sheath. This impoverished state of body especially favours the production of two very serious diseases, namely, tubercular consumption and glanders. These affections owe their origin to similar causes: their existence indicates a deteriorated and vitiated state of the blood, and their cure is all but hopeless.

Tubercular consumption is of less frequent occurrence in horses than either in the human subject or in cattle, and is rarely seen except in animals in which there is a strong constitutional predisposition to it. If this latent predisposition be excited in early life, the disease generally attacks the mesenteric glands and mucous follicles of the small intestines; these become enlarged, and filled with unhealthy pus and tubercular matter; the lacteal vessels are unable to take up the nutritive portions of the food, and the animal dies of inanition. In advanced life the tubercular deposits are more abundant in the organs of respiration. A gluey fibrinous matter appears on the surface of the mucous membrane lining the air-cells and the smaller bronchii. The more fluid portions of this are absorbed; and there remains a greyish yellow, cheese-like mass, incapable of organization, and containing numerous gritty inorganic particles. After a variable, but generally considerable time, these tubercles run on to unhealthy suppuration; large portions of the lungs become quite inadequate to the performance of their functions; the quantity of the circulating fluids is lessened by diarrhœa and dropsical effusions, and death results from extreme exhaustion. It is stated by Dr. Alison that the causes of pulmonary consumption and scrofulous diseases "may be all ranked together as causes of *debility* acting permanently or habitually for a length of time, although not so powerfully as to produce sudden or violent effects." * But there are few more powerful causes of debility than imperfect nourishment, and therefore we can scarcely deny its great influence in contributing to develop these intractable diseases. Indeed, it is well known that such diseases are remarkably common amongst badly-fed portions of the population, and that even amongst the most healthy inmates of prisons a

* Watson's Principles and Practice of Physic, 3rd edition, vol. i. p. 203.

scanty diet has produced, after some time, glandular enlargements of the neck and other symptoms of struma, which entirely disappeared when the prison discipline was somewhat relaxed, and the nutritiveness of the diet increased.*

Causes which in other animals give rise to consumption generally produce in the horse *glanders* and *farcy*. These diseases are essentially the same; they are induced by similar causes, characterized by similar post-mortem appearances, pass imperceptibly into one another, generally co-exist in fatal cases, and are, in short, but two different stages of the same constitutional malady. As induced by insufficient or bad food, farcy usually appears first, and may continue for some time before any symptoms of glanders present themselves. Both diseases depend upon a vitiated condition of the blood. This, in the first instance, causes irritation and unhealthy inflammation of the absorbent glands and vessels, which become swollen from the deposition of lymph and the inflammation of their valves. The effusion, however, is of a morbid character, and after some time runs on to suppuration; the skin overlying the part is removed by ulceration, and thus farcy-buds are formed. The poison is carried by the blood to all parts of the body, and, under certain circumstances, rapidly reproduces itself. Tubercles and unhealthy pus are deposited in all the lymphatic glands and in the substance of the lungs. The functions of digestion and assimilation are imperfectly performed, and the blood becomes so impoverished and vitiated as to be unfitted for the nutrition of the body. Ulcerations appear on the mucous membrane of the nostrils, which is attacked on account of its high vascularity: for those parts first undergo disintegration which require, for their healthy existence, the largest amount of blood. The time which elapses between the first development and the fatal termination of glanders is exceedingly variable, being sometimes a few weeks, and sometimes even years. With judicious management and feeding, a glandered horse may sometimes continue fit for work for a very long time; but the action of any debilitating cause calls forth, with unrestrained force, the latent disease, and hastens on the inevitably fatal result. All influences which deteriorate the general health or vitiate the integrity of the system must be considered as causes of glanders. It sometimes follows influenza, strangles, diabetes, and other debilitating diseases, and is notoriously the scourge of badly-managed stables. Three of its most frequent causes form three several heads of this essay, viz. insufficient food, overwork, and bad shelter; and all three, as indeed all other causes of the disease, so act as to reduce the powers of life below their natural healthy standard.

* Watson's Principles and Practice of Physic, 3rd edition, vol. i. p. 205.

Insufficient food frequently causes functional diseases of the digestive system. It produces atony, weakness, and perverted secretion, and is thus a common cause of indigestion, acidity, and occasionally of colic. It favours the development of intestinal worms, and by inducing hunger, or impairment of the functions of digestion, sometimes gives rise to crib-biting and wind-sucking.

There is no age at which animals are exempt from the evils of insufficient food, but there are certain ages at which they suffer more frequently and severely than at others. Thus the consequences of a scanty diet are more speedily produced, more aggravated and lasting, in very old and in young animals than in adults, and the reason is obvious. In old age, the powers of assimilation are often considerably impaired, waste is rapid, strength beginning to decline, and health and vigour can only be maintained by abundance of well-chosen nutriment; while in youth there is a twofold demand for new materials, which are required at this time not only for repairing the waste of all the tissues, but also for increasing their bulk. This twofold consumption of aliment, with the want of strength to resist depressing influences, sufficiently accounts for the marked effects of defective feeding on horses previous to maturity.

When insufficient food, as is too often the case, occurs in connection with other errors of management, its evil consequences become immeasurably increased. When insufficient quantity co-exists with bad quality of food, its effects are produced with ten-fold rapidity and certainty. Irritation of the alimentary canal, as indicated by diarrhœa and colic, is amongst the earliest consequences of this two-fold error. In such cases irritation of the kidneys is also often induced, and this, with an impoverished state of the blood, sometimes gives rise to diabetes. Insufficient food greatly aggravates the evils of bad shelter and exposure to rain and cold; it increases their tendency to induce catarrhs, pulmonary affections, ophthalmia, rheumatism, and such like diseases, by reducing the vigour of the body and its power to resist disease; while, in connection with want of cleanliness, it is a fertile cause and great aggravation of mange, grease, and other skin affections.

In fine, insufficient food is sometimes an exciting, but still more frequently a predisposing, cause of disease. It induces a debilitated and deteriorated state of the system, which resists ill the ordinary exciting causes of disease, favours the transmission of contagious disorders and the development of latent maladies, and lessens in all patients the hope of a speedy and favourable recovery. The evil consequences of a scanty diet often remain long after the error has been amended. All animals lose condition much faster than they can gain it. Thus, if the food of a

cow be deficient for one day, the milk is reduced in quantity for several days. Again, a starved colt often bears about with him for months, and even years, the unmistakeable evidences of an ill-judged economy in his early diet. It requires long good feeding to get him into condition, and he is in general less easily kept in condition than a horse well fed from his birth. Such facts show the great importance of supplying horses with a sufficiency of food at all times, and any sort of management which overlooks or ignores this fact must be inconsistent with the health of the animals and with the best interests of the proprietor.

(*e*) Before passing to the consideration of improper food we shall briefly notice an error in the dieting of farm-horses which is unfortunately very widely prevalent. It is this: much too long an interval is often allowed to intervene between the times of feeding. The animals are frequently worked for six hours consecutively, and during this time receive no food whatever. Such a practice is very prejudicial to the health of horses, preventing their being kept in good condition, rendering them prone to debilitating diseases, and especially liable to colic and almost all diseases of the digestive system. The natural habits of the horse and the conformation of his digestive system show that he has neither been intended nor is adapted to suffer such long fasts. When at liberty he eats during twenty of the twenty-four hours, and the smallness of his stomach clearly indicates the necessity of supplying him with food at frequent short intervals. Farm-horses should, therefore, be fed every four, or at most every five hours; and if there be a longer interval between the regular times of feeding, an intermediate meal should be given. This may conveniently consist of a cake, either of bean-meal, or of a mixture of bean and oatmeal. A pound weight of this, kneaded up with water and sufficiently fired, may be given to each horse; and for the field or road such food, when compared with hay or corn, has the great advantage of being speedily eaten, of affording much nutriment in a conveniently concentrated form, and of being little liable to be wasted. The author is acquainted with several farmers who give these cakes whenever the work is severe and the hours long, and all of them agree that their horses are now in much better heart and condition, and less frequently attacked by indigestion and colic, than they were when subjected to protracted abstinence and without any intermediate meal.

(*f*) Food may be *improper* on account of excess of quantity, over-nutritiveness, or bad quality; and under these several heads we purpose noticing the subject of improper food.

An *excessive quantity of food* consumed at one time is very apt to produce immediate bad consequences, as colic, enteritis, laminitis, and occasionally, from the great distension generally

present in such cases, rupture either of the stomach or intestines. Affections of this sort frequently occur amongst farm-horses, from the large quantity of food consumed after protracted abstinence, or from their getting loose during the night and gaining access to the contents of the corn-chest. In such cases food is consumed to an amount so unusually large that it is only very partially digested; in this case it soon undergoes chemical change, and becomes a source of irritation, and the intestines endeavour to relieve themselves of their load by those violent spasmodic contractions which form the characteristic symptoms of colic. The irritation, however, is sometimes so excessive that, unless natural or artificial aid be afforded, inflammation is set up. Frequently, too, the sensitive and vascular laminæ of the feet become inflamed, constituting *laminitis*, or acute founder. The production of this disease by excessive eating is generally accounted for by the doctrine of metastasis, or, in other words, by supposing that the irritation of the alimentary canal is transferred to the feet. In this, as in many other cases in which metastasis is said to occur, there is, however, no actual transference of the disease from one part to another, but merely an extension of the disease from its original seat to parts of similar structure, connected by continuity or contiguity of surface. And hence we find that, in cases of the rapid ingestion of large quantities of food, the consequent irritation of the alimentary canal extends to the laminæ of the foot, on account of their being endowed with great vascularity and sensibility.

Amongst the lower animals the evils of *continued excessive quantity of food* are sometimes conjoined with those of insufficient nutritiveness. Colts fed exclusively on straw, as is too frequently the case during winter, often afford examples of the combined effects of both errors. Straw contains so small a proportion of nutritive material that exceedingly large quantities of it must be consumed in order to supply the waste of the system. The usual consequences of such feeding are, a gradual enlargement of the abdomen, and the production of what is significantly termed a pot-belly. The overloaded intestines press forwards upon the diaphragm, and, by thus lessening the cavity of the chest and interfering with the respiratory movements, unfit the animal for active exertion. From the overworked condition of the digestive organs, indigestion and colic are also apt to occur.

Excessive quantity of highly nutritive food leads especially to plethora, weed, surfeit and other cutaneous eruptions, as well as to obesity and enlargement of the liver. Blood is manufactured in larger quantity than can be conveniently disposed of; and this plethoric state of body predisposes to affections of an acutely inflammatory type, to apoplexy, and to other diseases of the brain.

From the superabundant quantity and rich quality of the circulating fluids, irritation and inflammation of the absorbent vessels and glands are often produced, constituting the disease termed *weed.* This is especially apt to occur in plethoric subjects when their work is less severe than usual; and hence we find that the great majority of cases of weed follow a day of rest. In some horses an excessive growth of the fatty tissues is the consequence of such high feeding. In man a corresponding condition is considered disease, is termed polysarcia, and often leads to serious derangements of important organs. In the horse, however, it rarely causes actual disease, but always unfits the animal for active exertion. Horses fed for a length of time on large quantities of rich and stimulating food are very liable to *enlargement of the liver.* Such food requires for its proper digestion very large quantities of bile; and to meet this constant excessive demand the liver gradually becomes increased in size; affording a good illustration of the general rule, applicable to all the organs and tissues of the body, that the more a part is exercised the more highly is it developed. From the stimulating nature of their food, brewers' and distillers' horses in particular are very frequently affected with enlargement of the liver; and I have met with several cases in which the enlargement and softening of that organ were so great as to cause rupture and death.

Food is occasionally given to farm-horses in a state of *bad preservation.* The common error of this nature is the use of heated or musty oats or hay. Such food, by irritating the intestines, often gives rise to indigestion and diarrhœa; or, by stimulating the kidneys, produces diuresis and diabetes. When, from bad preservation or other causes, food is of a very defective quality, and forms for some time the whole or a great portion of the diet, it causes all those evils above noticed as resulting from insufficient food. Food, although of perfectly sound and good quality, and capable of forming healthy chyle and blood, sometimes disagrees with horses from its being entirely different from that to which they have been accustomed. It is frequently observed, for example, that, when farm-horses are put upon winter food, the turnips cause at first colic and derangements of the digestive system. And again, bean and pea straw, which is much used as fodder in some districts, is exceedingly apt to cause colic, unless at first given very sparingly; and yet, after a time, most horses eat large quantities of it with impunity. There are, however, particular sorts of food which always disagree with some horses, and to which they appear never to become habituated. I have known horses which were invariably seized with violent fits of colic whenever they ate a small quantity of turnips, while others were similarly affected by eating either bean or pea straw. Such

cases can only be accounted for on the supposition that the stomach and intestines become after a time accustomed to the stimulus of one particular sort of food, which the alimentary secretions soon become peculiarly adapted to digest. If food of an entirely different sort be substituted, some time is required before the digestive system responds perfectly to its stimulus, or the secretions become fitted for its easy and speedy digestion. In a few exceptional cases, in animals of peculiar constitution, and in regard to particular articles of food, this adaptation to the change of food does not occur at all, or only very tardily.

Before leaving the important subjects of insufficient and improper food we shall briefly recapitulate the following practical conclusions, deducible from the various subdivisions we have adopted in the consideration of the present head. To preserve farm-horses in health and vigour, their food must be of sufficient quantity and nutritiveness; it must be given at short intervals; it must not be too large in quantity, or too rich in quality; it must be in good preservation; and it must be changed only with great care, and by slow degrees.

2. *Overwork.*—Farm-horses, as a class, are not so frequently overworked as some sorts of horses. Their work is constant, but slow; and the hours of labour, although occasionally too long, are on the whole tolerably regular. Their diet also, in most of the best-farmed districts of the country, is liberal; and considerable care is paid to their general comfort. Under such management the horses are vigorous and healthy; and although their work may occasionally for a short time be severe, and the times of labour too protracted, still in adult seasoned horses this seldom of itself gives rise to disease. Very different, however, is the case where the animals are habitually overworked, especially when at the same time subjected to a deficient system of diet, bad housing, or the breathing of impure air. In such circumstances, overwork speedily and certainly reduces the strength and vigour, and becomes the exciting cause of some diseases, and the predisposing cause of others; the evil consequences induced occasionally occurring during the undue exertion, but more frequently some time after.

Amongst the most common and certain consequences of overwork are general depression of the vital energies and loss of natural vivacity and of condition. Loss of condition renders the horse very liable to galls from the collar and saddle, which are cured with difficulty, from the small amount of muscle and adipose tissue covering the bones, and from continuance of the hard work. The exhaustion engendered by overwork powerfully predisposes to many diseases. Inflammation of the various parts of the pulmonary apparatus, ophthalmia, and glanders, are, *cæteris*

paribus, more frequent visitants of stables where horses are overworked than where the work is moderate and judiciously regulated. And when disease attacks the overworked horse, his debilitated state of body often leads to untoward complications, interferes with the action of necessary remedies, diminishes the efficacy of the *vis medicatrix naturæ,* retards recovery, and hastens death.

The limbs of the horse exhibit most exquisite arrangements of parts and curious modifications of structure; powerful, solid, and unyielding levers; muscles condensed into the smallest bulk consistent with strength, or replaced by ligaments and tendons, of more compact and denser structure, and of untiring vigour; cartilaginous pads beautifully adapted for sustaining pressure and obviating concussion; joints whose perfect form excites the admiration of the most accomplished mechanicians, and from the study of which they have derived several valuable contrivances; an extensively distributed apparatus, to elaborate and contain an oily fluid for lubricating this wonderful machinery, for preventing friction in joints and facilitating motion of tendons; and at the base of all, supporting the whole weight of the frame, and often exposed to violent concussion, an agglutinated mass of hair, forming the strong, inelastic, non-vascular, and insensible hoof, and affording perfect protection to the highly vascular and sensitive structures contained within it.

But although this locomotive apparatus is of great strength, and adapted to sustain with impunity a great amount of exertion, yet it is often quite inadequate to those tasks of strength or fleetness to which it is sometimes subjected, in ministering to the avarice, wants, or pleasures of man. Indeed, there is scarcely a disease of the extremities which is not produced either directly or indirectly by excessive or long-continued overwork.

In violent exertions the bones are sometimes fractured, particularly the bones of the fetlock; but this seldom occurs, except during more rapid work than usually falls to the lot of farm-horses. Laceration of muscular fibre is occasionally met with. The best illustration of this occurs in the disease generally termed *shoulder-slip*, which consists in a tearing of some of the muscular fibres of the antea or postea spinatus, or the teres externus—muscles lying on the outer part of the shoulder-blade. We shall notice this accident somewhat in detail, as it does not seem to have attracted that attention which it deserves. It appears to be more common in Scotland than in England. It generally occurs in young horses, shortly after they are put in the plough, or in older animals not previously accustomed to such work. The consequence is, that, from a false placing of the feet, and the horse being hurried on by his companion, the muscles of the shoulder

are brought into sudden and violent action, and rupture of some of the minute muscular fibres takes place. The animal falls lame, but the lameness is often scarcely perceptible. The muscles affected, being kept in a state of inaction, become atrophied, or wasted, to such an extent that the spine and tubercle of the scapula are often felt quite distinctly, and the bone seems in close contact with the skin. From this wasting of the muscles which keep the shoulder-joint in its position, it is thrown outwards at every step, giving the animal a rolling, unsteady gait. The treatment of such cases consists at first in rest, and subsequently in gentle and gradually increasing exercise. The application of a blister may sometimes be advisable.

Strains of the tendons of the fore-leg are a very common consequence of overwork. The disease, as met with in farm-horses, generally occurs first in the metacarpal ligament, just above its insertion into the tendo-perforans. From exposure to undue tension, several of the fibres of this important ligament are torn, and great pain is in consequence felt, whenever the limb is extended, as when the foot is placed on the ground. Unless the animal be prevented from using the limb, much inflammation takes place, and also effusion, which, by separating the fibres of the ligament from each other, deflects them from their straight course, thus producing at the same time thickening and shortening of the limb. From the excessive pain, and the endeavours to relieve the strained ligament as much as possible, undue stress is frequently thrown on other parts of the limb; and hence, when a horse is still kept at work, the perforans tendon and suspensory ligament soon become also involved. The tendo-perforans is also liable to strain, lower down in its course, near its insertion into the bone of the foot, and just where it passes over the navicular bone. From injury done to this part of the tendon it becomes inflamed, the inflammation extending to the bursæ lying within the tendon, and subsequently, in more aggravated cases, to the bone itself. Friction is produced by impaired synovial secretion, and roughening of the opposing surfaces by effusion; and this gives rise to a very characteristic sort of lameness, a short, tripping, yet careful gait, a peculiar method of standing with one foot projected, a wasting of the muscles of the shoulders, upright pasterns, and a red, inflamed appearance of the sole, especially round the point of the frog. In short, the animal is groggy. He is affected by *navicular disease*, a disease so common as to be familiar to every one having the most limited experience in horseflesh.

But besides diseases of the bones, muscles, and tendons of the extremities, overwork also produces diseases of the tissues of the joints and of the feet. Subjecting animals whose limbs are not

of the strongest conformation to continued hard work, often gives rise to diseases of the joints, by causing undue friction. To relieve this friction an unusually large quantity of synovia is poured out, as in *bog-spavin.* This palliation of the evil is often, however, insufficient; the friction still continues, inflammation extends from the synovial fringes to the cartilages; and this occurring in the hock, or in any of the larger joints, eventually renders the animal useless. Friction occurring between tendons, or between a tendon and any other tissue over which it moves, gives rise to *wind-galls*, the most unfailing, although certainly not the most serious, consequence of hard work. They consist in puffy swellings of the synovial bursæ, or bags placed to facilitate motion between different parts of the limb. They are usually found about the fetlock, and generally in connection with the bursæ, between the tendo-perforans and tendo-perforatus, or between the tendo-perforans and suspensory ligament. Although various diseases of the foot appear in connection with overwork, still they cannot be considered as depending upon it alone, but are rather induced by its co-operation with other causes, such as peculiar formation of the feet, or improper shoeing. In connection with these, overwork is a fertile cause of *corns*, and also of *contraction.* Its influence in producing *laminitis* will be noticed presently.

The evils of *overwork* are very *remarkable in young horses*, that is, in animals below the age of five or six, because their strength and power of endurance are not so great as in adult life, and their bones, muscles, and all other structures are still growing rapidly, and want firmness and solidity. On this account, hard work, or any other depressing agent, produces its effects more speedily and certainly before than after maturity. In some parts of the country it is the practice to put horses to work much too young, often many months before they are three years old. Those who adopt this practice generally advocate it on the principle that the animals require exercise, and that such exercise is beneficial to their growth. This is certainly undeniable; but the exercise to which the young horse is subjected is constant unremitting toil, and not the healthful beneficial exercise which he requires, and which he would naturally take. In consequence of such mismanagement, when the animal is five years old, instead of being healthy, vigorous, well-formed, and full of animation, he is a miserable, jaded, worn-out, dull, and spiritless creature; his limbs weak, and probably mis-shapen from injudicious wear and tear; his spirit crushed by the hard usage received in urging him to tasks to which his strength was unequal; and if not absolutely unsound, his debilitated constitution renders him an easy victim to many serious diseases. In short, from an ill-judged economy,

too often the cause of such mismanagement, a few months' work is gained at the expense of years of good service, and a useful animal is virtually rendered aged before reaching maturity; for certain it is that undue work during early life and before the animal is fit for it brings on premature old age; nor do we think we over-estimate the evil when we say that a year of future usefulness is lost for every month that the colt works before he is fit for it.

The colt intended for agricultural purposes, if well grown and carefully nurtured, may be taken up for work when two and a half years old; but for at least six months after he should not have more than three or at most four hours' work per day, and that only of the lightest description. With a quiet, steady neighbour, he may be employed for light ploughing, or may be yoked in the thrashing-mill. Until four years old, the amount and times of work may be gradually increased; and at this age the animal will be fit for all ordinary farm-work, except heavy carting, for which he should not be used until at least five years old.

There are two diseases to which overworked young horses are especially liable—splint and spavin. *Splints* are bony tumours, situated between the cannon bones and the small splint bones, and generally occurring on the inside of the fore limbs. They rarely cause lameness, except during their formation, and when high up on the limb. They are produced by an abnormal activity of a perfectly normal process. The bones above mentioned are, in early life, united to each other by a cartilago-ligamentous connection; but about the time of maturity osseous matter is produced, by which they become firmly cemented together. If, during this natural process, the animal is made to use his limbs for fast or severe work, active inflammation is set up in the soft tissue between the two bones, apparently as a natural provision for strengthening the parts as rapidly as possible, by uniting the two bones into one. But from the undue action to which the parts have been subjected, the inflammation still continues; and after the bony cement is produced, osseous matter is deposited in nodules. These constitute splints, and until the inflammation is subdued they continue to cause more or less lameness. The inflammation and lameness may be overcome by rest and appropriate treatment; and although the splint still remains, the lameness is cured.

Many horses become the victims of *bone spavin,* from being injudiciously worked at an early age. This disease is especially apt to occur in animals with upright hocks, and in cases where the width below the hock is disproportionately small as compared with that above it. Spavin, like splint, is caused by inflammation of the ligamentous connection between two bones. It appears on

the antero-internal part of the limb, usually between the metatarsal bone and the cuneiform medium, but in some cases between the two cuneiform bones, to which also in severe cases the inflammation often extends. Spavin appears to be brought about, in the first instance, by pressure and concussion, which cause injury and inflammation of the parts just referred to. This inflammation gradually converts into bone the ligamentous connections between one or more of the tiers of bone forming the hock. During this formation of bone the pain and lameness are most intense, and permanent relief is rarely obtained until the ossification is completed, which, even in favourable cases, prevents all motion between the smaller bones of the hock.

Work to which an animal has not been accustomed, and for which he has not been prepared, is often productive of very injurious consequences. A certain regulation of diet and a certain amount of previous training are absolutely necessary before a horse can with safety perform labour even of moderate severity. Ignorance or neglect of this fact often gives rise to disease. It is, for example, no uncommon thing for a farmer to purchase horses that have stood for some considerable time in a dealer's stable, where they have probably become fat from soft feeding and want of exercise. The purchaser, naturally enough wishing to test their powers, puts them to the work of seasoned horses, and is surprised to find them fail in satisfactorily performing their allotted tasks. But more than this: serious disease is often the consequence of such severe and sudden trials; and the purchaser, although in error, thinks himself imposed upon, and frequently seeks redress at law.

Derangements of the digestive system and laminitis often result from overworking horses that are out of condition. Affections of the lungs are also frequent among those employed for rapid action, but are less common among agricultural horses.

For the proper performance of digestion and assimilation a large amount of blood and nervous energy is required. When, however, an animal, previously unaccustomed to it, is subjected for some time to excessive hard labour, there is an unusually great expenditure both of blood and of nervous power; and as some time elapses before this loss can be repaired, the functions of digestion are much retarded, part of the food undergoes chemical change, and causes irritation, as indicated either by colic or *diarrhœa*. The latter complaint, especially in young horses with large flat sides, is a very common consequence of such mismanagement, and, unless the diet be attended to, often continues for a very long time, the food meanwhile passing through the intestines in a crude and undigested state.

Laminitis, or, as it is also termed, acute founder, consists in

inflammation of the delicate sensitive laminæ of the foot. It may be caused either by the unwonted stress which overwork imposes directly upon these structures, or by derangement of the digestive system and of the skin. Violent exertion frequently induces laminitis, by increasing to excess the functions of the skin, and thus rendering it unusually susceptible of the action of cold. From the exhaustion of the system which usually obtains in such cases, and from the undue elevation of the surface heat, the cold operates as a powerful sedative; the blood leaves the surface and collects round internal organs, and the secretion of the skin is arrested, and all its functions are impaired. The laminæ, however, are merely skin modified to serve a special end; they are continuous with it, and are affected by the same agencies which influence it. On account, however, of their extreme vascularity and sensitiveness, they are far more speedily and intensely acted on by any cause of disease, and hence these laminæ are often excited to acute inflammation by causes inadequate to inflame other portions of the skin. Such is the manner in which we believe most cases of laminitis to be produced by the influence of overwork.

3. *Insufficient shelter.*—In a climate such as ours, and in the absence of epidemics and epizoötics, the great proportion of disease, both in man and the lower animals, is traceable to variable or low temperature. In man a direct relation is observable between temperature and the prevalence of disease. "Temperature," says Dr. Guy, "is beyond all doubt the most influential cause of disease."* The tables of the Registrar-General also establish the fact that a cold season or winter is always accompanied by a high rate of mortality.†

Insufficient shelter acts injuriously on all animals, chiefly by exposing them to sudden changes of temperature and to the influence of excessive cold, winds, rain, and storms.

Animals in good health and abundantly supplied with food do not suffer much inconvenience even from very great cold, if unaccompanied by moisture. Of this we have sufficient evidence in the fact that horses, as well as other animals, living at high altitudes, and in climates much colder than ours, enjoy unimpaired good health. In such animals, however, there is an unusual expenditure of heat, in consequence of the contact of the cold air, the greater evaporation and radiation from the surface of the body, and the increased density of the inspired air. To compensate for this unusual loss, a *larger supply of food is necessary* than for animals surrounded by and breathing a warmer air. In short,

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* Statistical Journal, vol. viii.—Paper on the Influence of Seasons on Sickness and Mortality, p. 137, *et passim.*

† Eighth Annual Report, p. xxxvii.; Combe's Physiology of Digestion, p. 87.

a more rapid combustion is necessary to maintain the heat of the body, and a larger quantity of fuel must be supplied to support that combustion. "The cooling of the body," says Liebig, "by whatever cause it may be produced, increases the amount of food necessary." * Sheep exposed to the inclemency of winter weather eat much larger quantities of food and fatten more slowly than those in sheltered situations and receiving the same sort of food. The milk yielded by cows is often much diminished if the animals are exposed to cold, even for a short while. Indeed, amongst all animals, the effects of cold are greatly aggravated by insufficient food. Their conjoined influence on man is thus clearly stated by Sir John Richardson:—"During the whole of our march we experienced that no quantity of clothing could keep us warm while we fasted; but on those occasions on which we were enabled to go to bed with full stomachs we passed the night in a warm and comfortable manner." †

When air at low temperatures is set in motion, as by *winds,* the sensation of cold becomes much aggravated, and sometimes almost unbearable. In such cases, however, there is no diminution in the temperature of the air. During the keen piercing winds which occasionally sweep over our island, the thermometer indicates that degree of temperature which, in the absence of these winds, would be considered mild and agreeable. This influence of winds, in aggravating the effects of cold, has been noticed by most Arctic voyagers. Thus it is stated by Parry, that he and his crew suffered more from cold in a breeze with the thermometers at 32° Fahr. than in calm weather with the thermometers at zero. The explanation of this is very obvious. Cold air in motion causes more rapid evaporation of fluid from the skin than air at rest of the same temperature; for it speedily displaces the atmosphere of warm humid air which surrounds the body, and substitutes instead fresh quantities of air at a lower temperature, and hence possessed of greater heat-abstracting power. In this way we may in part account for the great consumption of food, the tardy growth, and poor condition of badly-sheltered horses.

But insufficient shelter, besides exposing horses to the evils of cold, also affords them imperfect protection against undue *moisture.* The inhalation, for any considerable length of time, of an atmosphere surcharged with moisture, cannot but exercise a deleterious influence on the animal body; for such an atmosphere contains, in proportion to its volume, less oxygen than drier air, and possesses a power of diffusion considerably inferior to it. This diminished power of diffusion interferes with the full and rapid arterialization of the blood—a process on the due activity

* Familiar Letters on Chemistry, p. 73.

† Franklin's Journey to the Polar Seas, vol. i. p. 421.

of which depend life and health. The presence of moisture in the atmosphere does not necessarily reduce its temperature, but appears to modify the action of that temperature, and to render it more hurtful. Moisture also promotes decomposition and facilitates the transmission of infectious disorders. When conjoined with undue warmth, moisture has a powerfully relaxing effect, and thus prepares the body for the favourable reception of the exciting causes of disease. But when it occurs in connection with cold, it is then that dampness induces its most frequent and serious evils—its power being thus increased tenfold. It abstracts heat and electricity from the body, interferes with the important functions of assimilation and secretion, arrests the cutaneous exhalations; and thus gives rise to abnormal changes in the blood, to the retention of effete particles, and to the imperfect renovation of the plasma. Such are the general effects of the conjoined action of cold and wet, and to this conjoined action may be ascribed many of the worst evils of insufficient shelter.

Shelter may be insufficient, either from the exposed position of pasture-lands or of farm-steadings, or from the faulty construction or bad repair of the stables, courts, or sheds, in which animals are housed. The general effects of these different sorts of bad shelter do not however materially differ. It would appear at first sight a very natural supposition that an animal should suffer less when placed in a draught or current of cold air than when completely surrounded by an atmosphere at the same temperature; because in the former case the cold acts only on one particular part of the surface, while in the other it acts upon the whole surface. Experience, however, leads us to a very different conclusion. But, although every one admits the danger of currents, few consider the manner in which they prove injurious. When a healthy animal is placed in a cold atmosphere, the cold, unless very intense, stimulates all the vital functions to increased activity; the respirations are increased in force and frequency; the inspired air is dense, and hence contains a large quantity of oxygen in proportion to its bulk; and thus the animal heat and vigour of the circulation are maintained unimpaired. But the case is very different when cold is applied locally by a current of air. The part subjected for some time to its sedative influence becomes bloodless, its functions disturbed, and its secretions arrested. The effects of the cold are not sufficiently extended to induce the necessary reaction; the balance of the circulation is disturbed, and then inflammation of predisposed parts is the usual consequence. Disease is thus often produced in small and badly constructed stables. These, from being overcrowded, and from want of appliances for efficient ventilation, often become overheated; and to remedy this evil the doors and windows are

thrown open, admitting currents of cold air. The previously heated, and, it may be, fatigued condition of the animals, predisposes them to suffer from this mismanagement; and many serious and fatal catarrhs, bronchitii, and pulmonic affections are traceable to such errors.

If horses, especially after continued severe exertion, remain exposed to inclement weather, or are put into stables where they are rapidly cooled by draughts, the vessels on the surface of the body become constricted by the action of the cold, and blood is driven in excessively large quantity to the internal organs. These soon become surcharged and oppressed with blood, and their functions impaired and arrested. The balance of the circulation is thus disturbed, and effete matters are retained; and from the operation of these two causes inflammation is produced. This inflammation attacks those parts which are weakest and least able to withstand the assaults of disease. Hence, according to the predisposition of the animal, and in proportion to the amount and duration of the exposure, insufficient shelter will induce inflammation of various parts of the respiratory apparatus and of the eyes, derangements and diseases of the bowels, feet, and kidneys, rheumatic affections, and general depression of the vital energies.

In localities where shelter is wanting or insufficient, *diseases of the respiratory organs* are unusually frequent and severe. The mucous membrane lining these organs is particularly apt to suffer. In the horse, the membrane is very vascular and sensitive, and covers a large extent of surface. In the nostrils, it is thick, and copiously supplied with large blood-vessels, and assumes a condition very similar to erectile tissue. It is this peculiarity of conformation which predisposes the horse to *catarrhal affections,* or, as they are familiarly styled, "colds in the head." These consist in inflammation of that portion of the respiratory mucous membrane which lines the nostrils and sinuses of the head. Dryness of the parts affected is soon succeeded by copious discharge, at first of a thin watery fluid, and subsequently of a thick muco-purulent one. The eyes are also red and weeping; for, as usually happens in such cases, inflammation speedily extends to surfaces of like structure and close proximity. There is more or less feverishness, as indicated by the impaired appetite, quickened pulse, and unequal surface heat. The inflammation often extends downwards, and involves other parts of this extensive mucous membrane. It sometimes attacks that portion lining the larynx, and, from the effusion produced, the symptoms are often very acute, and the issue precarious. More commonly, however, it affects that portion of the mucous membrane which lines the trochea, bronchii, and minute air-cells, causing *bronchitis.* The principal phenomena attending this disease are the same as in

catarrh, namely, effusion and fever. The particular symptoms are modified by the structure and functions of the parts affected, and are described in detail in most treatises on veterinary science. Other parts of the respiratory apparatus besides the mucous membrane are also apt to suffer from inclemency of weather. Horses exposed to low temperatures or stormy winds, or placed in currents of cold air, especially when the vital functions are in a state of depression, are sometimes attacked by *pneumonia* or inflammation of the substance of the lungs, but still more frequently by *pleurisy* or inflammation of the serous membrane which covers these important organs, and is reflected over the inner walls of the chest. Diseases of the respiratory organs, produced by exposure, exhibit some characteristic features, which distinguish them from the same class of diseases resulting from other causes. These diseases affect, to a greater or less degree, almost all parts of the respiratory apparatus; the mucous membrane is involved throughout most of its extent, from the nostrils to the ultimate air-cells, as also the tissue of the lungs and their serous covering; and death usually results from suffocation, caused by the large quantity of frothy mucus poured into the trachea and bronchii.

Many of the diseases affecting the eye often originate from insufficient shelter. There is no cause of simple *ophthalmia* or inflammation of the conjunctiva—the mucous membrane of the eye—so frequent as cold. Nor is it an unfrequent cause of that more serious and deep-seated inflammation of the eye, known amongst veterinarians by the name of specific ophthalmia. When the exciting cause is slight, and its continuance transient, the more external of these inflammations is generally produced; but when very intense, or of long continuance, the more deep-seated usually occurs. The latter is often attended by very aggravated symptoms, is tedious and troublesome of cure, apt to induce cataract, and always predisposes the eye to suffer from a return of the inflammation.

The influence of weather on *affections of the bowels* is not so obvious as on those of the respiratory organs. The same inclement weather which produces in most horses catarrh, bronchitis, or pleurisy, occasionally gives rise to *enteritis*. This is most apt to attack horses with flat ribs, and those subject to indigestion and colic. Such cases of enteritis are exactly similar to those produced by other causes. They are characterised by the same symptoms, require the same treatment, and run their course with the same frightful rapidity, sometimes destroying life in six or eight hours. When horses are plentifully supplied with good food, steady and continued cold rarely causes *diarrhœa*. This affection, however, is frequently produced by sudden alternations

of temperature, or the conjoined action of wet and cold, and in such circumstances is often very troublesome and apt to become habitual. It is the same disease as catarrh or bronchitis, except in situation. It depends on irritation of the mucous membrane, and of the mucous follicles abundantly distributed on it, and which pour out an excessive quantity of fluid.

Exposure to wet and cold, by deranging the functions of the skin, sometimes induces *laminitis,* especially if the horse be overheated and exhausted from severe or long-continued work. The production of laminitis in such cases has already been noticed under the second head of this essay, and therefore need not be again adverted to here.

When horses, previously well housed and tended, are exposed to rain and cold, they are occasionally attacked by *inflammation of the kidneys,* which frequently results from the continued dropping of rain on the loins, or from exposure to drifting snow or sleet. The disease, however, is not of very frequent occurrence in the horse, but most cases of it result either from the above-mentioned causes, from injudicious feeding, or from the excessive action of powerful diuretics; and not, as is generally stated, from blows or external injuries, which cannot, we think, seriously affect organs so deep-seated and protected as the kidneys. *Nephritis,* or inflammation of the kidney, is ushered in with ordinary febrile symptoms: the pulse is accelerated, but soft, from the large amount of mucous membrane involved; the bowels are out of order; there is sometimes diarrhœa, but more generally constipation; the animal walks with a straddling gait, and if turned round grunts with pain. When one kidney only is affected, the stiffness and lameness are confined to the corresponding side; the urine is diminished in quantity, and altered in quality; it is sometimes mixed with pus, sometimes with blood; when voided, it may be liquid, or in clots or shreds: the pulse after a time becomes much accelerated, and symptoms of coma appear, depending upon arrested action of the kidneys, and accumulation of urea in the blood.

In exposed situations the fibrous and fibro-serous are very apt to become affected by *rheumatic inflammation.* This variety of inflammation is principally confined to these fibrous tissues, is attended by fever, manifests a marked disposition to shift from one part to another, and differs from ordinary inflammation in its terminations, for it does not run on either to suppuration or gangrene. Some animals have a greater disposition to it than others; but this predisposition may be engendered, even in the healthiest subjects, by exposure to cold and wet. Such agencies appear to induce rheumatism, by causing an abnormal congestion of the internal organs, and arresting the cutaneous excretions. Effete

matter is thus retained in the blood, exciting irritation in the congested parts, and especially in the fibrous tissues. The symptoms of rheumatism vary with the parts involved. When the inflammation is principally confined to the fascia of the muscles of the neck and back, it constitutes what is termed the *chords.* This affection is attended with stiffness and tenderness of the neck and back, inability to elevate or depress the head, and great difficulty and pain in moving. The febrile symptoms are often violent, and there is a full, strong, incompressible pulse —a very characteristic symptom of all rheumatic affections. Such cases are often troublesome, generally lasting some weeks, but they are not in general very dangerous. The joints, and especially the larger ones, are sometimes the seat of rheumatic inflammation; but this form of the disease is less frequent in horses than in cattle. It is attended by stiffness and inability to move, pain on pressure, and more or less fever. The inflammation attacks one or two of the joints, and then, leaving them, involves others, and, in bad cases, the pleura and pericardium are often affected. This tendency of the disease to shift from one part to another is, we think, an unanswerable argument in favour of its being a disease depending upon some change in the blood, and not a mere local affection.

Insufficient shelter, besides being a potent *exciting* cause of disease, is also a *predisposing* cause of many and various maladies. It produces depression of the vital energies, and hence renders animals subject to its influence especially liable to epizoötic diseases. From its debilitating and deteriorating influence, it leads to phthisis pulmonalis, and glanders and farcy. Further, it produces a habit of body which aggravates the character of many diseases, renders them unusually intractable, and apt to assume untoward complications. Animals reared in such unfavourable circumstances are long in coming to maturity; they have in general a miserable and unthriving appearance, their skins are thick and hard, and their hair long and coarse.

But to conclude, we may remark, by way of recapitulation, that the insufficient sheltering of farm-horses is productive of many and various evils. It causes an unusually great consumption of food, and even with the most liberal diet good condition is rarely attainable. It produces disease, sometimes by causing sudden and great derangements of the circulation, and sometimes by depressing the vital energies. By the former mode of action it generally induces phlegmonous or acute inflammation; by the latter pulmonary consumption, glanders, and farcy. In short, insufficient shelter may be considered as *the* special exciting cause of all affections of the respiratory organs and of all rheumatic inflammations, and a powerfully predisposing cause of almost every disease.

4. *Neglect of Incipient Disease.*—There unfortunately prevails amongst farmers a disposition to overlook or think lightly of the premonitory or incipient symptoms of disease. Even after an animal is discovered to be ill,—and this, from carelessness or want of observation, is not always so early as it ought to be,—much valuable time is often lost in supinely waiting to see if the case will spontaneously improve, or in the employment of useless or injudicious measures. In many diseases of the horse such procrastination is productive of very serious injury, often inducing permanent unsoundness and even death, and always prolonging the duration of the malady, and increasing the difficulty of treatment.

Certain indications or signs, or, as they are technically termed, *symptoms,* always precede and accompany disease. These serve the important purpose of attracting attention to disease, and are therefore safeguards against its extension or increase. The symptoms which in the horse indicate the *approach of internal disease* are generally of a febrile character. The animal is dull and listless, or restless and uneasy; the surface heat unequal, the ears and extremities cold and the mouth hot; the digestive functions deranged and the appetite impaired or capricious; the pulse slightly accelerated and the respirations hurried. When an animal shows several of these symptoms, and, still more, all of them, he should be narrowly watched; if in plethoric condition blood may with advantage be abstracted, and a laxative administered; and on the earliest manifestation of the localization of the disease other appropriate remedies should be promptly used. The symptoms manifesting incipient disease of the extremities are more or less pain when the parts are put in motion, unwillingness to use the affected parts; in short, lameness and tenderness. These symptoms, although easily observed, and often as easily traceable to their causes, are frequently neglected. The horse, instead of getting a few days' rest and a little attention, is still kept at work, until perhaps he can go on no longer. The nature of the case is then for the first time examined, and its treatment commenced; but, from the previous procrastination and neglect, several weeks of rest and of proper medical treatment are often required to render him fit for work.

In the ordinary affairs of life "there is a tide which, taken at its flow, leads on to fortune;" so also, in the treatment of disease, there is a time when remedies are most likely to be attended with success, and that time is undoubtedly the early stage of disease. All diseases at their outset are more manageable than they are after a time. Thus, in the case even of the more serious local inflammations, the symptoms are at first few and simple, and perhaps not very intense; the powers of nature are strong and

active, and the action of remedies comparatively certain. Unless, however, a change for the better is either naturally or artificially brought about, the number and intensity of the symptoms go on increasing; the conservative power of nature becomes impaired; the disease, from being merely local, involves the whole system; the digestive functions are deranged, the circulation, and hence the respiration, affected; morbid changes are in progress; and remedies act slowly and uncertainly, and are often quite ineffectual in controlling or subduing the now fully developed disease. In *pneumonia*, or inflammation of the lungs, for example, there is at first merely coldness of the surface, cough, fever, slightly accelerated pulse or breathing; and well-directed measures will often entirely and speedily avert further evil effects. Should this stage, however, be allowed to pass unattended to, these symptoms become aggravated; effusions are poured into the areolar structure of the lungs, become organised, and, as no treatment whatever can remove them, they often, even when recovery takes place, interfere with the important functions of respiration, and permanently impair the integrity of the organs.

There are, we believe, but few diseases which do not afford the clearest and most incontrovertible evidence of the importance of early judicious treatment, and the injurious consequences of the neglect of such treatment. This is however chiefly observable in acute diseases. It is well shown, for example, in *enteritis*. In the horse this disease sometimes runs its fatal course in six hours, and even in four; and unless the earliest symptoms be noticed and combated, there is but little hope of a successful issue. The inflammation affects the mucous coat of the intestines, exhibits great tendency to spread to all parts of this delicate and sensitive membrane, and also involves the serous and muscular coats. It is on this account that such cases are so unmanageable; for the rapidly extending inflammation and great amount of effusion produce such a shock, and cause so much debility, that death speedily ensues.

Wounds, when neglected, frequently take on very unfavourable conditions, which ordinary attention might have easily prevented. Simple incised wounds, from want of cleanliness, often run on to suppuration; and in certain situations, where matter or other irritants are permitted to accumulate, sinuses and fistulæ are frequently induced. Thus, slight injuries about the poll or withers, or in the neighbourhood of ligamentous and fibrous tissues, when not properly attended to, often run on to the formation of extensive, deep-seated, and tedious wounds. Pricks and other injuries of the foot, when promptly attended to, are generally easy of cure; but when neglected, give rise, amongst other diseases, to sinuses or quitters, which pass in various directions, destroying the con-

nections between the hoof and the vascular parts of the foot, involving sometimes the coffin-bone itself; and months of patient and unremitting care are often ineffectual in restoring the parts to health.

Before leaving this head, we purpose briefly noticing a few of those *diseases of the extremities* which are most apt to be *aggravated by inattention* to their incipient symptoms. There is no case in which neglect of a simple ailment so frequently and certainly induces serious and permanent disease as in that very common affection termed *strain of the back tendons*. This often at first consists in the laceration of only a few tendinous fibres, which with rest soon reunite, and the animal is restored to soundness. But if kept at work, the laceration increases, violent inflammation is established, and thickening contraction and permanent unsoundness are the inevitable consequences. *Bone spavin,* when noticed early, is sometimes checked by rest and soothing treatment; the different parts of the hock being thus kept sound and perfect. When spavins, however, are not early attended to, and especially if the horse continues at work, the inflammation attains such intensity that it cannot be subdued until ossification has taken place between some of the bones forming the hock. It is to hurry on this unavoidable termination that blisters, firing, and such other remedies are so often employed; but the cure is accomplished only at the expense of entire loss of motion between the several bones forming the lower part of the hock; and although the animal may go sound, he always goes stiff. A similar result obtains in the case of *curb*. This consists in a strain of the calcaneo-cuboid ligament—a ligament which passes down the postera-internal surface of the os calcis, or prominent bone of the hock. It is at first tolerably easy of cure; but if neglected or improperly managed, thickening and ossification take place. Spavins, or, as they are called by way of distinction, *bog-spavins,* also afford a good illustration of the retributive justice which overtakes neglect of the incipient symptoms of disease. In these cases we find in the first instance the capsular ligament of the hock-joint distended by an excessive quantity of synovia, secreted to lessen the irritation set up by previous friction. Unless there be a repetition of the exciting cause, this curative effort of nature may be successful, and with rest soundness may be restored. If, however, sufficient time be not allowed for a perfect cure, the joint becomes permanently thickened by deposition of lymph; and sometimes even osseous matter is produced, uniting the bones of the hock into one unyielding bony pillar. I have seen several specimens of such cases of *anchylosis* of the bones of the hock, resulting from disease of the joint, and in which all parts of the hock were ossified except the tendons and the grooves in which they lay.

In many of the more hilly parts of the country young horses at pasture are subject to a species of *dislocation of the patella,* the bone being jerked inwards at every step the animal takes. In very aggravated cases there is little hope of perfect recovery, as there is generally knuckling over at the fetlock, which renders the animal perfectly useless. It is only, however, from the most culpable neglect that such cases assume a serious aspect; for when observed and attended to sufficiently early, they are generally entirely cured by the adoption of very simple measures, such as the removal of the animal to soft and level pasturages, and the putting on of light shoes. The following case, which recently came under my observation, shows at the same time the importance of arriving at a correct diagnosis, and also the evil of delaying the adoption of proper remedial measures. Several horses were standing together in an innkeeper's stable, and one of them made a kick at his neighbour, and struck him a few inches above the hock, on the inside of the hind limb farthest from him. As, however, there was little apparent lameness, and no swelling or injury of the skin, the animal was put to work as usual, but was soon seen to move on three legs. On examination there was found to be *fracture of the tibia* with displacement; and the animal was destroyed. In this case the kick must have produced fracture more or less complete, but without displacement; and had the nature of the case been at first fully ascertained, and the animal kept at rest for a few weeks, perfect recovery would have taken place. But instead of this, the animal was put to work, which caused entire separation of the parts, and prevented all hope of a speedy and satisfactory recovery.

From inattention to shoeing, and neglecting to relieve a tender sole from undue pressure, corns are produced. These, when uncared for, multiply and reach the quick, causing much lameness, and, it may be, suppuration and detachment of the hoof. A trifling sandcrack, when neglected, often extends through the whole crust, and months of care may be required before the breach is perfectly repaired. A slight injury of the anterior part of the foot, or inattention to a badly-adjusted clip, frequently produces seedy-toe. Neglect of cleanliness gives rise to thrushes; and mismanaged or neglected quitters to false quarter.

But we must now leave this head, not because we have exhausted the subject or the illustrations that might be advanced to show the evils of neglect of incipient disease, but because a further discussion of the subject would involve much repetition, without strengthening materially our arguments, while the illustrations that might be adduced are numberless, seeing that the principle applies to almost every disease and injury to which the horse is liable.

5. *Want of Medical Skill in Professional Attendants.*—It is difficult to estimate the amount of evil arising from want of medical skill in professional attendants. Such want of skill may operate injuriously in almost every disease. It may be shown either by injudicious treatment, or by failing to employ proper treatment—it may consist either in doing positive harm or in failing to do good—it may do too much, or not enough. In short, there is no error, great or small, into which want of skill may not lead the practitioner. And to refer, however briefly, to all the circumstances and diseases amongst horses, in which want of skill is sometimes shown, would be to notice almost every affection to which the horse is liable. It will, however, we believe, be more in accordance with the intention of the proposed head if we confine our observations to the mistakes and errors which most frequently occur amongst persons of some professional standing.

Want of medical skill in the *treatment of disease* is sometimes shown in the employment of unsuitable remedies, and also in the injudicious use of proper remedies. This, we believe, is often the case with *bloodletting* in inflammations of the respiratory apparatus. In many such cases the medical attendant is not called in until the second or third day—until the intensity of the inflammation has passed away. The patient, however, is examined, and the case pronounced to be pneumonia, pleurisy, or bronchitis. If the practitioner be one of those who treat diseases merely according to their names (and there are still too many such), he immediately abstracts blood, on the ground that bleeding is placed first among the remedies for such diseases, and is moreover the "sheet-anchor for the cure of inflammation." A more intimate acquaintance with the phenomena of such inflammations would, however, have taught the practitioner that the treatment adopted, although very suitable for the early stages of the disease, could be of no service in the latter stages, when effusion had taken place, and the more acute inflammation had been thereby overcome; and that such treatment could only retard recovery, by debilitating the patient to no purpose. It appears to us that the great majority of veterinary surgeons are in general much too fond of bloodletting, and often practise it where it can do no good, and may do much harm. As above stated, they often err in employing it when the time has passed for its being of any use. This and similar errors depend in great part upon a morbid love of intermeddling, and a determination to do something—faults, however, for which the veterinary practitioner is not always accountable, since his employers are seldom content to leave matters to the curative powers of nature, thinking that the more physicking, bleeding, and medical treatment

the patient gets, the better. This mistake appears to be prevalent in many parts of the kingdom, but especially in some of the more wealthy manufacturing districts. Such opinions are, however, very erroneous, and the practice to which they lead is often extremely injudicious. The evils of such practice are chiefly observable in some of those catarrhal affections occasionally occurring, as epizoötics, in most varieties of that ill-defined disease influenza, and in all the exanthemata or eruptive fevers. Such diseases generally run a certain definite course, and whatever interferes with that course is productive of more or less injury; they show a marked tendency to spontaneous recovery, require only the use of measures which second the efforts of nature, and are far more frequently mismanaged by too much than by too little treatment.

From these remarks it will be apparent that the medical attendant may sometimes betray want of skill in employing remedies in all stages of a disease which are suitable only in one stage; in treating cases of the same disease in exactly the same manner without any regard to modifying circumstances; in intermeddling with diseases which are best left almost entirely to nature; or in attempting to alter the fixed and natural course of disease.

But want of professional skill, besides being often apparent in the treatment of disease, is perhaps still more so in the *diagnosis* and *prognosis* of disease. This is clearly shown in the various contradictory statements made by different practitioners concerning the same case, as may often be seen in the annals of veterinary jurisprudence, and the reports of many of our courts of law. How often, for example, do we find the most conflicting opinions entertained on questions of *soundness!* How faulty and absurd are the ideas sometimes propounded concerning the nature of diseases! How fallacious the opinions often given of the probable duration of particular cases, and of the time required for the production of certain morbid appearances of death! How common the error of mistaking one pathological condition for another, as congestion for inflammation—a chronic debilitating disease for an acute and inflammatory one—a simple and curable malady for a severe and incurable one!

There may occasionally be some difficulty in distinguishing between normal and abnormal appearances; the gradations between health and disease being often so slight and imperceptible that it is difficult to say where the one ends and the other begins; and hence perfectly *healthy conditions* are sometimes *mistaken for morbid conditions, and vice versâ.* Thus, many horses have been rejected as unsound, in consequence of the opening through which the optic nerve passes being mistaken for

cataract. Indeed, the highest perfection of form has frequently been mistaken for disease. Many animals have been condemned as spavined on account of the remarkable development of the natural roughened eminences on the antero-internal part of the hock around the anterior and inner part of the cuneiform bones. This conformation, however, instead of showing weakness or disease, gives strength and power by affording mechanical advantage for the insertion of muscles and tendons. The natural ridge extending round the small pastern-bone is also apt, when prominently developed, to be mistaken for *ring-bone.* True ring-bone, however, is situated lower down, and immediately above the upper part of the hoof, and often exists in only one limb; whereas the ridges and tuberosities to which we have referred will be found alike in both limbs, and only in limbs which show in other parts considerable irregularities and asperities. The sulcæ and cavities found in the cartilages of the larger joints have, by some, been mistaken for ulcerations; and one gentleman, of high standing in the profession, has stated that the presence of these cavities in the hock-joint was the cause of obscure hock lameness. Unfortunately, however, for the credit of this opinion, such cavities are found in many, nay, in most, sound hocks, and are placed there for the important and express purpose of spreading the synovia, or joint-oil, over all parts of the joint. They have many characteristics which distinguish them from cavities caused by inflammation: their edges are smooth and glistening, and they are lined with vascular synovial fringes. These few instances show the want of skill of some practitioners in mistaking healthy for diseased conditions, and strengthen our conviction that the veterinary practitioner should have an accurate knowledge of healthy structure and functions, as well as of morbid structure and functions; or, in other words, of anatomy and physiology, as well as of pathology.

There is, perhaps, no class of cases which brings the skill of the veterinary surgeon to a severer test than injuries or diseases of the extremities, or, as they are significantly termed, *lamenesses.* In the horse these are very numerous; they occur in almost every part and tissue of the limbs, and are sometimes difficult to detect, as they are often concealed from view, not being perceptible except by nice manipulation, while their symptoms are apt to be falsely interpreted. A knowledge of the anatomy and physiology of the parts affected, and a certain amount of experience and of manual tact and dexterity, are the only sure means of detecting lamenesses and arriving at their accurate diagnosis and prognosis.

Want of medical skill in professional attendants is now much less common than it was even a few years ago; and in most localities where agriculture is in an advanced condition, and stock numerous and valuable, there are to be met with veterinary

surgeons of liberal education, and possessed of a competent knowledge of both the principles and practice of their profession. This improvement in the skill and education of veterinary practitioners is, we believe, the result not of one, but of several, causes. It has been brought about by the increased value of all the domesticated animals, by the spread of knowledge among agriculturists, by the necessity consequently felt throughout the country of having skilful and thoroughly educated men to whom to confide the medical care of stock; and it has also been promoted, in no small degree, by the valuable instructions now afforded at both the London and Edinburgh Veterinary Colleges in all departments of veterinary knowledge. Farther, the Royal English Agricultural Society and the Highland and Agricultural Society of Scotland have materially contributed to the advancement of veterinary science, and to the consequent improved position of its practitioners, by their active exertions and liberal support. The salutary influence of these two Societies on the improvement of veterinary knowledge can scarcely, we think, be over estimated. By patronage and pecuniary aid they have extended and improved the courses of professional study; by premiums for papers on various veterinary subjects they have elicited and disseminated very important information concerning the management of animals both in health and disease; and, by the personal interest which so many of their most influential members take in the advancement of the veterinary art, the profession is rapidly attaining that status to which its importance and usefulness so justly entitle it.

XXII.—*The Chemical and Agricultural Characters of the Chalk Formation.*—By J. Thomas Way and J. M. Paine.

The following analyses may, it is hoped, in some degree, assist the practical agriculturist residing in the district of the chalk, not only in the use, as manure, of the different marls and chalks which are here described, but also in the cultivation of the soils which are situated on one or other of the series in question. The character and composition of the soil in one field is seldom exactly repeated in the next, and the analysis of a particular soil is for the most part of local and individual interest only. Where, however, the different geological strata have well-marked characters, and the surface is comparatively free from foreign drift, it will be evident that the soil, however much altered by cultivation, will largely partake of these characters, and that a knowledge of the composition of the stratum will be a general guide to that of all the soils which are situated upon it.

I am quite willing to admit that the analysis of soils is not at present what the friends of agricultural chemistry might wish. We have much yet to learn before we shall be enabled confidently to point out the relation existing between the chemical composition and agricultural capabilities of a soil; but that such a connection does exist we cannot for a moment doubt, and we must regard the present unsatisfactory state of our knowledge on this subject as a defect inseparable from the early stages of any and every branch of human knowledge. Our true wisdom is, to wait patiently whilst we work manfully, assured that success cannot fail ultimately to reward the earnest and persevering search after truth. As effect follows cause, so *must* the agricultural capabilities of a soil, under given conditions of climate, culture, and mechanical structure, be in precise relation to its chemical composition. I fully anticipate, therefore, that practical agriculture will one day derive immense benefit from this department of applied chemistry.

In the meanwhile no fact that can be added to our present knowledge will be without its share in contributing to the ultimate result. It is true that it may be left for others to incorporate these isolated observations, and to give them a connected and rational form; but because the building of the house is necessarily delayed, it does not follow that the stones should be left unshaped in the quarry. It is a mistake to speak of *barren facts*: there are no such things; facts are the indispensable materials of philosophical generalization, and their acquisition must in all cases precede a knowledge of the principles upon which they depend.

It is hardly necessary that I should mention that the practical observations and descriptions of the different strata are those of Mr. Paine, to whose kindness I also owe the collection of the specimens for analysis. Whilst Mr. Paine's local knowledge of the strata of the chalk in his district is a sufficient guarantee of the identity of the samples with the members of the series which they profess to represent, the ample experience which he has gained in his own operations, as well as in the careful observation of those of others, enable him to speak to the value of the respective soils as manure. I consider myself particularly fortunate in having induced him a second time to join me in these investigations.

J. T. Way.

The following specimens of chalk and chalk-marl subsoils, comprising the whole series of the distinctive strata of the chalk formation from the gault clay to the upper chalk, *in ascending order*, were taken in a sectional line, over a distance of about four miles, from south-east to north-west, at right angles with the upthrow of the strata in the extreme west corner of Surrey and

the adjacent parts of Hampshire; that is, from near Wrecklesham church, in the parish of Farnham, to Crondell church, in Hampshire.

The specimens, in every instance, were dug out of the true geological subsoil, three feet below the surface of the ground. The lower members of the series crop out at no very considerable distance from each other—in some cases in the same field—while the upper one, constituting the soft chalk with flints, lies nearly parallel with the existing surface for many miles in a west-north-west direction, in fact, throughout the extent of North Hants into Wiltshire.

So far as regards the external and agricultural characteristics of the series of subsoils of which the chemical history is now given, this section may be considered a fair type or representation of the chalk of the South of England; and we have observed, in various localities in Hants, Surrey, Sussex, and Kent, that the preference has always been given, for marling and chalking purposes, to certain definite geological strata in the series, whenever they were within reach of the farm, as the marl and chalk pits of the older and present time abundantly testify.

No. 1. *The Lower Gault.*—This, the lowest part of the gault, is a blackish compact shaley clay. It rests upon the lower greensand, from which it is separated by a thin seam of phosphoric fossils (described by us in vol. ix. of the Society's Journal), generally accompanied by a thin band of impervious ironstone, which resists the passage of water, thus rendering this portion of the gault useless for agricultural purposes in its natural undrained state. From this cause also the oak trees growing here are always stunted in appearance; but whenever, by natural or artificial means, the obstruction from below is removed, this portion of the gault clay immediately becomes susceptible of great fertility.

As it always lies in close proximity to light sandy or gravelly soils it has been often used, and practically found to be a valuable alterative to such land, either directly by communicating its mineral ingredients, or by furnishing an absorptive medium for the retention of manure.

The Analysis of the Lower Gault (No. 1), when dried at 212° Fahr., is as follows:—

	Per Cent.
Combined water with a little organic matter .	7·68
Soluble in dilute acids, 23·32:—	
Silicic acid* (silica)	16·65

* Those readers who are acquainted with analytical chemistry will understand that the silica here stated to be soluble in acids is that which by *treatment of the soil with acids* is rendered soluble in caustic potash or soda, which it would not be but for such treatment. Its quantity indicates the extent to which the aluminous silicates are decomposed by the action of mineral acids.

	Per Cent.
Carbonic acid	none.
Sulphuric acid	traces.
Phosphoric acid	ditto.
Chlorine	0·03
Lime	0·66
Magnesia	0·77
Potash	0·66
Soda	·15
Protoxide and peroxide of iron	3·16
Alumina	1·24
Insoluble in Acids, 69·00 :—	
Lime	trace.
Magnesia	ditto.
Potash	1·53
Soda	1·90
Alumina with a little oxide of iron	19·06
Silicic acid and sand	46·51
	100·00

No. 2. *The Middle Gault.*—This is a stiff clay, of a bluish grey colour, and is usually more extensively developed than No. 1. Small nodules of carbonate of lime are pretty generally interspersed throughout it. Fossils, very rich in phosphate of lime, are also frequently met with, but they are in so complete a state of preservation, so intensely hard, that they probably exercise very little influence on its vegetation. This marl or clay has been extensively used on light soils, which it greatly improves, more so even than the lower gault—most likely by reason of the greater proportion of lime which it contains. When deeply and thickly drained it produces the very best crops of hops, wheat, beans, oats, and every variety of root crops. In its natural state it grows oak trees of magnificent size.

Analysis of the Middle Gault (No. 2).

	Per Cent.
Combined water with a little organic matter	6·38
Soluble in dilute acids, 50·81 :—	
Silicic acid (silica)	26·89
Carbonic acid	3·13
Sulphuric acid	0·30
Phosphoric acid*	trace.
Chlorine	ditto.
Lime	5·34
Magnesia	0·35
Potash	0·74
Soda	·31
Protoxide and peroxide of iron	7·25
Alumina	6·50

* In selecting a sample for analysis the phosphoric fossils were rejected.

Insoluble in acids, 42·81 :—	Per Cent.
Lime	1·61
Magnesia	·91
Potash	2·16
Soda	·42
Alumina with a little oxide of iron	7·88
Silicic acid and sand	29·83
	100·00

No. 3. *The Upper Gault* is of a dirty yellowish colour, not quite so stiff and tenacious as the lower members. The agricultural characteristics, after drainage, are very similar to those of the middle gault. We have never seen it employed as an alterative manure; neither would we recommend it, on account of its comparative deficiency in lime—at any rate, wherever the middle gault could be procured.

Analysis of the Upper Gault (No. 3).

	Per Cent.
Combined water with a little organic matter	5·47
Soluble in dilute acids, 31·85 :—	
Silicic acid (silica)	24·80
Carbonic acid	none.
Sulphuric acid	trace.
Phosphoric acid	ditto.
Chlorine	·03
Lime	·75
Magnesia	·26
Potash	·35
Soda	·16
Protoxide and peroxide of iron	4·56
Alumina	·94
Insoluble in acids, 62·68 :—	
Lime	1·29
Magnesia	·82
Potash	1·57
Soda	·64
Alumina with a little oxide of iron	11·29
Silicic acid and sand	47·07
	100·00

The above divisions of the gault are arbitrarily made, but we have employed them as they are readily recognizable, though each one gradually shades off into the other. The middle division is naturally the most productive.

No. 4. *Soft rock above the Gault.*—Immediately above the gault, with the upper member of which it insensibly intermingles, lies this soft white-brown rock, having the *appearance* of a rich limestone. It is very remarkable on account of its low specific gravity, and still more so, considering its position, by reason of the very small quantity of carbonate of lime which it contains. There are

numerous small fissures in the rock, which constitute a natural drainage. It is one of the richest subsoils of the whole chalk series, being admirably adapted for the growth of hops, wheat, beans, &c.; and indeed nearly the whole of the outcropping of this subsoil from Farnham to Petersfield is under cultivation for the first-named crop. When exposed to frost this rock crumbles into a fine powder. In the neighbourhood of Farnham, during the last ten years, many thousands of tons have been dug and used as a manure, under the impression that it was a "good marl;" this is so far mistaken as regards the meaning of the word *marl*, which, correctly speaking, should only be applied to a substance containing much carbonate of lime. All those persons who have employed it concur in expressing a favourable opinion of its effects, and particularly on some sandy soils the benefit derived from its application is most striking. That we are not to attribute this effect to the presence of lime in any form, is evident from the composition of the substance as given below.

At the present time it is still extensively quarried for manure. This section of rock at Farnham is about 40 feet in thickness, and as it approaches the next stratum above it gradually assumes a harder character, and does not so readily moulder into soil by exposure.

Analysis of Soft Brown Rock immediately above the Gault (No. 4).

	Per Cent.
Combined water and a little organic matter	4·15
Soluble in dilute acids, 57·10:—	
Silicic acid (silica)	46·28
Carbonic acid	none.
Sulphuric acid	trace.
Phosphoric acid	ditto.
Chlorine	none.
Lime	0·26
Magnesia	·07
Potash	·79
Soda	·43
Protoxide and peroxide of iron	6·12
Alumina	3·15
Insoluble in acids, 38·75:—	
Lime	2·91
Magnesia	traces.
Potash	1·51
Soda	·60
Alumina with a little oxide of iron	14·20
Silicic acid and sand	19·53
	100·00

No. 5. *The Firestone Rock.*—The next in the ascending series is the firestone rock, which is hard, heavy, and compact. It is much esteemed, locally, as a good building-stone, which may be

dug out in masses weighing several tons each. Between these masses of stone there are large fissures filled up with a rich unctuous marl. In these, when quarrying stones in hop-grounds, the roots of the hop-plant are frequently found 20 feet and upwards below the surface. This rock is not used as manure, and it decomposes very slowly; but whenever it crops out or runs near to and parallel with the upper soil the land is always of the most fertile description.

Analysis of the Firestone Rock (No. 5).

	Per Cent.
Combined water with a little organic matter	1·60
Soluble in dilute acids, 83·38:—	
Silicic acid (silica)	not ascertained.
Carbonic acid	35·47
Sulphuric acid	a trace.
Phosphoric	0·15
Chlorine	0·4
Lime	44·90
Magnesia	·28
Potash	·18
Soda	·30
Protoxide and peroxide of iron	·60
Alumina	1·46
Insoluble in acids, 15·02:—	
Lime	·41
Magnesia	·10
Potash	·07
Soda	·43
Alumina with a little oxide of iron	·92
Silicic acid and sand	13·09
	100·00

It will be seen that this rock differs from all the other strata that we have yet described, in being a comparatively pure limestone, containing 80 per cent. of its weight of carbonate of lime.

No. 6. *Fossiliferous Green Marl.*—This is a thin stratum, usually found from 12 to 20 feet above the building-stone. It varies in thickness from a few inches to 15 or 20 feet. Just at the bottom of this marl the phosphatic fossils lie in the greatest abundance. These, with the marl, have been fully described in vol. ix. of the Journal, in the paper "On the Phosphoric Fossils of the Chalk Formation." *

* It may not be uninteresting to state, that since the discovery of these phosphatic remains I have extensively and exclusively used the above fossils, as well as those still more abundantly obtained from the lower greensand, as substitutes for bones in the manufacture of superphosphate of lime for the use of my farm; and that, both as regards cheapness and efficacy, I have every reason to be satisfied with their employment for this purpose.—J. M. PAINE.

Analysis of the Fossiliferous Green Marl (No. 6).

	Per Cent.
Combined water and a little organic matter	4·21
Soluble in dilute acids, 64·61:—	
Silicic acid (silica)	31·88
Carbonic acid	small quantity, undetermined.
Sulphuric acid	·45
Phosphoric acid	3·76
Chlorine	trace.
Lime	5·61
Magnesia	·85
Potash	3·21
Soda	1·20
Protoxide and peroxide of iron	16·91
Alumina	·74
Insoluble in acids, 31·18:—	
Lime	1·52
Magnesia	1·09
Potash	·45
Soda	·31
Alumina and a little oxide of iron	5·75
Silicic acid and sand	22·06
	100·00

We have elsewhere drawn attention to the composition of this remarkable marl, and shall only here observe, that, in addition to the unusual percentage of phosphoric acid and potash it contains, it is not unlikely that some part of its fertility is connected with the quantity of silica present in a soluble condition.

No. 7. *Grey Marl.*—The grey or dirty-white marl rests upon the green band. It is frequently from 50 to 100 feet in thickness, shading off into the next division. This of all others is *the* marl which has been most extensively applied as manure in all parts of the outcropping of the chalk hills; and in very remote times it seems to have been most highly appreciated, if we may judge by the quantities that have been excavated. In some localities it is denominated "malm." On exposure to weather it falls into a fine powder. We need hardly observe that it is a most fertile subsoil, suitable to the growth of almost every crop.

Analysis of the Grey Marl, or "Malm" (No. 7).

	Per Cent.
Soluble in dilute acids, 78·65:—	
Silicic acid (silica)	2·16
Carbonic acid	29·96
Sulphuric acid	·21
Phosphoric acid	·21
Chlorine	·08
Lime	41·52
Magnesia	·30
Potash	·26
Soda	1·64
Protoxide and peroxide of iron	2·20
Alumina	·11

Insoluble in acids, 21·35 :—

	Per Cent.
Lime	1·71
Magnesia	trace.
Potash	·32
Soda	·07
Alumina and a little oxide of iron	2·57
Silicic acid and sand	16·68
	100·00

No. 8.—This rock is of a harder texture than the preceding one, and falls to pieces in flakes, instead of into powder, when exposed to frosts; it has therefore never been so much esteemed for marling purposes, neither is the soil formed from this rock so naturally fertile as any of the preceding. It will grow good wheat and barley, but it requires more manure. It is not suited for hops.

Analysis of Marl (No. 8).

	Per Cent.
Soluble in dilute acids, 92·74 :—	
Silicic acid (silica)	2·11
Carbonic acid	36·73
Sulphuric acid	·06
Phosphoric acid	·05
Chlorine	·04
Lime	49·16
Magnesia	1·18
Potash	·11
Soda	1·36
Protoxide and peroxide of iron	1·74
Alumina	·20
Insoluble in acids, 7·26 :—	
Lime	·22
Magnesia	trace.
Potash	·15
Soda	·05
Alumina with a little oxide of iron	1·42
Silicic acid and sand	5·42
	100·00

No. 9. *Lower Chalk.*—This is an extremely hard chalk, of rather a yellowish colour. It lies between the preceding marl and the chalk, with flints. It is very much mixed up with broken chalk fossils, which, however, are non-phosphoric. Frost exerts very little influence over this chalk, causing it merely to split into laminated plates. It is seldom employed as a dressing for land. As a soil, it is usually of a poor character, probably the poorest of the whole series; but after deep subsoiling, combined with proper manuring, Mr. Paine has succeeded in growing upon it heavy crops of wheat, barley, and turnips, even when there was a very scanty portion of surface-soil.

Analysis of Lower Chalk (No. 9).

	Per Cent.
Clay and sand insoluble in acids	2·04
Silicic acid, soluble in ditto	trace.
Carbonic acid	42·14
Sulphuric acid	·31
Phosphoric acid	·07
Chlorine	none.
Lime	54·37
Magnesia	·25
Potash	·08
Soda	·19
Protoxide and peroxide of iron	·55
Alumina	trace.
	100·00

No. 10. *Lower Portion of Chalk, with Flints.*—This is a softer chalk than the preceding. It pulverises to a considerable extent on exposure, but not thoroughly, like the upper member, or free chalk next to be described. This bed (No. 10) is of interest, as underlying, *just beneath the surface, the greater part of North Hants.*

Analysis of No. 10.

	Per Cent.
Sand and silicious matter insoluble in acids	·66
Carbonic acid	42·98
Sulphuric acid	trace.
Phosphoric acid	·08
Chlorine	none.
Lime	55·24
Magnesia	·10
Potash	·06
Soda	·14
Oxide of iron and alumina	·74
	100·00

No. 11. *The Upper Soft White or Free Chalk* crumbles into a fine powder, like slaked lime, on exposure. It is always selected, where attainable, for the chalking of soils, for which purpose enormous quantities have been dug, from time immemorial. At Odiham, in North Hants, there is a pit of chalk of this description, probably the most extensive of its kind in the kingdom. The specimen analyzed was taken near Crondell church, in a field of about 100 acres, in several parts of which, by way of experiment, bones were thickly applied as a manure some twelve or thirteen years ago, after which there was a most marked superiority in each crop of the four-course shift, the portions where the bones were put being conspicuously visible in the crops. There is a thin top-soil, of light hazel loam, lying on the chalk in this locality.

Analysis of No. 11.

	Per Cent.
Sand and silicious matter insoluble in acids	1·46
Carbonic acid	41·48
Sulphuric acid	none.
Phosphoric acid	·04
Chlorine	none.
Lime	55·72
Magnesia	·06
Potash	·17
Soda	·02
Oxide of iron and alumina	1·05
	100·00

No. 12. *Second Specimen of Upper Chalk*, taken from a pit where chalk is dug for manuring purposes, lying about half a mile north of the preceding specimen. Both the soil and subsoil of this locality possess the same external characteristics as those of No. 11.

Analysis of No. 12.

	Per Cent.
Sand and silicious matter insoluble in acids	·87
Carbonic acid	42·57
Sulphuric acid	·09
Phosphoric acid	·08
Chlorine	·08
Lime	55·18
Magnesia	·30
Potash	·22
Soda	·21
Alumina and oxide of iron	·40
	100·00

Little need be added to what has already been said with regard to these different soils. Nos. 1, 2, and 3, the different portions of the gault, are not properly marls but clays; the middle gault being indeed the only one containing any carbonate of lime. No. 4 is an exceedingly singular stratum; and it is not improbable that a further careful study of this soft light rock will aid in throwing light upon the internal composition of soils, of which at present we know little or nothing. The samples 5, 7, and 8 contain a considerable proportion of clay, and are therefore properly called marls; whilst the last four specimens are all chalk, more or less pure.

XXIII.—*On the Diseases occurring after Parturition in Cows and Sheep, with the Remedies, &c.* By W. C. Sibbald.

Prize Report.

In accordance with the first of the regulations laid down as guides to competitors for the prize of the Society, the author has, in this

treatise, confined his remarks as much as possible to his own personal observations, surgical practice, and remedies: this will account for the plain style in which it is written. He has also (as a member of the veterinary profession) found it a matter of some little difficulty, in the construction of a report intended for the information of the agricultural community at large, to abstain from the use of technical phrases, so that it may be generally understood—a matter which he ventures to assume is of paramount importance: in accordance with this view, it is proposed very cursorily to notice the parts immediately connected with parturition, giving at the same time their anatomical names, which will then be made use of throughout the consideration of the diseases consequent upon this process. First then of the uterus. This is the hollow organ known as the womb or calf-bag, and in which the calf is contained, with its membranous coverings, during the period of pregnancy; these membranes, three in number, constitute the placenta or after-birth. The inner surface of the uterus is studded with numerous prominences, each placed at some little distance from the other, and adherent to similar projections on the outermost covering of the fœtal calf: these projections are denominated the cotyledons. The uterus gradually contracts in size towards the opening leading from it, and this contracted portion is termed its cervix or neck: the opening itself is the os uteri, which during pregnancy is hermetically closed, but when the act of parturition commences it is capable of being vastly dilated to allow the passage of the fœtus.

The os uteri opens into a passage of some length and considerable size; this is the canal of the vagina, which terminates at the vulva, or external opening, familiarly known as the shape or bearing; the sides of this opening consist of two prominences, designated the labia. These observations, and the nomenclature, will in every particular apply to the ewe and its fœtal lamb.

The diseases incidental to the Cow will form the first part of the Report, and it will be necessary for the better elucidation of the subject to notice, first, the manner in which this animal should be treated after natural and healthy parturition. The act of delivery being fully accomplished (which includes the expulsion of the placental membranes), the cow should be allowed to lick and caress her offspring, and as soon as she becomes tranquil the greater part of the milk contained in the udder may be withdrawn. In some parts of the country it is a common practice to allow the cow to drink this first-drawn milk, or beastings; it is not, however, advisable to follow this practice, as no benefit accrues to the beast, and it will disincline her to drink the warm water or thin oatmeal gruel which should as speedily as possible be offered to her, and supplied in liberal quantities for the succeeding twenty-

four hours. The calf may be allowed to suck as soon as its strength will permit; but if, as is frequently the case in dairy counties, the young animal is intended to be reared from the pail as soon as dropped, the portion of milk left in the udder may remain until the next milking without fear of any unpleasant result. As diet, the cow may be allowed some warm bran-mash and a moderate quantity of hay, but cut fodder and roots of all kinds should be avoided during the first few days; if it be the season of grass, she should be put up and restricted to the same diet for the same period; some extra shelter suitable to the season of the year must also be afforded her at this time.

Disease in its varied forms comes next to be considered; and the one most frequent of occurrence (affections of the udder excepted), and most important on account of its fatality, is that known by the various terms of "Milk Fever," "Dropping after Calving," &c.

Modern practitioners of Veterinary Medicine have designated it "Parturient Apoplexy;" and as the name has reference to one of the most prominent symptoms in connection with the process which it follows, it is perhaps not inappropriate.

The animal, however, that has dropped after calving, and is unable again to rise, may yet present a variety of symptoms, only some of which, or modified states of the same, are present in different cases, and this difference will have a corresponding influence upon the treatment. This disease will very rarely be found to supervene upon difficult parturition; on the contrary, it usually selects for its victims those animals which have had an unusually quick and easy delivery; no breed is exempt from its attack; the Alderney has been said to have this immunity, but such is not the fact; it will however more frequently be met with in the well-bred short-horn. Few cases occur in heifers, or at the second calving; the greater proportion are animals with their fifth or sixth calf, but they are frequently attacked both before and after these latter periods. Beasts with large udders, and that are in the habit of yielding great quantities of milk, are more particularly obnoxious to it; the time of its occurrence after calving varies from a few hours to three days, and it does sometimes make its appearance after a longer interval, but this is the exception to the rule. The earliest symptoms are an appearance of restlessness, shifting of the limbs, increased brightness of the eye, and the dung is frequently evacuated; then follows quickened breathing, unsteadiness in the gait, and at length the animal falls, makes one or two ineffectual attempts to rise, and then gradually, and often rapidly, appear some or all of the symptoms about to be noticed. In some cases the pulse will only average from 55 to 60 beats in the minute, being full and steady, in fact

scarcely deviating from the ordinary and natural pulse; the horns, extremities, and surface of the body are cool, the nose moist, no appearance of inflammation about the udder, but the secretion of milk is much diminished; the animal has no appetite, and rumination is suspended; the shape is open and flabby, and there is frequently a discharge of white tenacious mucus proceeding from it; the pupils of the eyes are dilated, the eyeball looking blue and glassy; in a short time the head will be turned backwards, the nose resting in the flank; the horns, extremities, surface of the body, and udder, now become colder, and the animal passes into a state of coma; the breathing in some cases is heavy and stertorous, in others there is no visible alteration; the eyeballs are now fixed, the finger may be passed round the inner surface of the orbit without any sense of feeling being manifested; eructations of fetid gas will rapidly succeed each other up the gullet; possibly the paunch will be distended with this gas, constituting hoove; the *number* of pulsations remains the same, but the *force* is much diminished, indeed sometimes the pulse can hardly be felt; neither dung nor urine has been voided since she fell; she never changes her position, but if you raise her head it falls helplessly upon her side, and thus gradually life passes away, generally in about twenty-four hours from the commencement of the attack. In other cases the symptoms, as soon as the beast has fallen, are more violent: the pulse ranges from 70 to 80 beats per minute, the breathing is quickened, the horns are hot, the nasal pad dry, the udder is hard and hot, she froths at the mouth, moans, and makes desperate but ineffectual struggles to rise, no feculent matter or urine is evacuated, the pulse increases in frequency, but is less distinctly to be felt, the respirations are increased to perhaps 40 in the minute, and in seven or eight hours the state of coma before adverted to supervenes, death rapidly following. There is yet another state known under the name of dropping after calving; in these cases the animal falls about the second or third day; she can raise herself upon her fore limbs (in fact some of them will sit up like a dog upon their haunches), but she cannot make any effort with her hind limbs, yet the appetite continues good, rumination is accomplished, the secretion of milk is plentiful, and the evacuations are natural; in this state she may remain from two to five days, or even longer, and at length rise upon her legs and completely recover.

It is a notable fact, that upon making an examination of the bodies and viscera of some animals that have died from this disease, so trifling will be the deviations from a healthy appearance, that it becomes a matter almost impossible for the examiner to point out the immediate cause of death; nevertheless there are

sometimes sufficient lesions to be found which may be taken as evidences of the nature of the disease: occasionally the blood-vessels of the dura mater, or membrane investing the brain and lining the bones of the skull, will be found to contain a larger quantity of dark-coloured blood than usual; this appearance will extend to the portion covering the medulla oblongata, or commencement of the spinal marrow, but no farther.

The vessels of the lungs are often inordinately filled with blood; the cavities of the heart will also be found to contain large quantities of dark-coloured fluid blood. In some cases the liver is in a state of congestion, the gall-bladder may contain more or less bile, the thickness of which is mostly in an inverse ratio to the quantity. The rumen, or first stomach, is invariably found to contain a large quantity of food in an undigested state: the second stomach will also contain food; and here, too, the greater portion of the fluids taken after the commencement of the disease will be found: the contents of the third stomach are generally dry and hard; the lining membrane of all three is easily separable from the subjacent tissue, and appears of a purple hue: the fourth, or true digestive stomach, will contain but little ingeste; if any medicine have been administered, some of it will be found in this stomach; the lining membrane will be thickened and of a scarlet hue, and this appearance will extend several inches along the commencement of the intestines, and frequently for some little distance beyond this the intestine will be deeply stained with bile. Throughout the remaining course of the small intestines no trace of food will be found; but here and there they will be contracted as though from an attack of spasm, while in other parts the mucous lining membrane, and even the peritoneal covering, will present a similar appearance to the fourth stomach; occasionally some fæcal matter will be contained in the large intestines, but more frequently they also are empty, even to their termination at the anus; the bladder may or may not contain urine, but the viscus itself generally presents a healthy appearance. The last organ to be noticed is the uterus, and seldom indeed is it that any trace of disease can here be found: according to the time that has elapsed, so will be the appearances of recent delivery; the cotyledons are more or less absorbed, generally presenting a brownish hue, and some little fluid will be found contained in the cavity. From the varied symptoms during life, and uncertain appearances after death, it is little to be wondered at that, even in the present day, some difference of opinion prevails among the members of the veterinary profession as to the primary seat of this disease.

The treatment next comes under consideration. If an animal be found suffering from the disease in its earliest stage, or before

she has fallen, the state of the pulse should be ascertained as quickly as possible: this may be felt, as in the horse, at the artery passing over the angle of the lower jaw; if there be plenty of blood distending the vessel, which may be known by the force with which it pulsates under the finger, the number of beats will be of little moment, but the jugular vein should be immediately opened, and from four to eight quarts of blood abstracted, according to the size of the animal; it will often be necessary to have several men to support her upon her legs during this operation, but perseverance will not unfrequently be rewarded by the prevention of her dropping at all, and her complete and rapid recovery. Should the animal, however, be down before attention is called to her, the propriety of blood-letting will become a matter of anxious consideration. As a general rule it is better to abstain from it, but the state of the pulse will be the guide to the professional attendant: if it be but little quickened, or indistinctly to be felt, and the extremities, &c. are cold, or if the animal is in a lethargic state, by no means bleed; but if the pulse range from 70 to 80 in the minute, sharp in its beat, the animal struggling and throwing itself violently about, and more especially if she have but recently dropped, benefit will be obtained by opening the jugular; but the operator must now carefully watch the effect of loss of blood upon the pulse: should it become slower, or if it falter, or miss a beat, let the vein at once be pinned up. Some medicine will in all events next be administered, and this must consist of a powerful cathartic; no other proof need be adduced of the necessity of this beyond the fact that if the animal live long enough for purging to be brought about, recovery with ordinary care is almost the invariable result, and often the more prominent unfavourable symptoms will disappear, as if by magic, when purging commences. To the cathartic should be added powerful stimulants in large doses: the first dose, for a strong, fresh, full-sized beast, may consist of two pounds of Epsom salts, with one dram of croton oil for the cathartic, and, as stimulants, the ordinary mustard flour and spirits of turpentine, of each from two to three ounces, with one or two ounces of ginger; or, if there be any preference, an equal quantity of sulphur may be substituted for some of the salts, and the stimulants may be varied by the nitric spirits of ether, the aromatic spirits of ammonia, and powdered gentian-root, in doses of two ounces each; these last, however, are less efficacious than the former, and it must be borne in mind that it may be impossible to administer a second dose, from the great difficulty in swallowing about to be noticed. The medicines should be gradually mixed with three or four quarts of tepid water, and then slowly and carefully poured down the animal's throat: this will be a

work of some little time, requiring from the exhibitor the exercise of a considerable amount of patience, as the power of deglutition is much impaired in this disease, and there is danger of suffocation to be apprehended from some portion of the draught passing into the windpipe. The cow must now be raised and maintained as much as possible, with the aid of trusses of straw, &c., in a natural position, resting on her chest and belly, with an inclination to one side; the body should be clothed, if rendered necessary by the lowness of its temperature, or the temperature of the surrounding atmosphere. And here it may be remarked that the disease will make its appearance at all seasons of the year; but, as in dairy counties almost all the cows calve in the spring or early summer, so, as a matter of course, it is more prevalent at that time in those counties. All the milk that can be abstracted should be drawn from the udder; the attendant should ascertain if there be any fæces in the rectum, and if so, remove them with the hand: a gallon of warm water, in which a little soft soap has been dissolved, should then be thrown up with a clyster apparatus. It is a customary practice to apply some powerfully stimulating liniment to the spine, and this is certainly advisable, it being remembered that every symptom points to functional derangement of the brain and nerves; the liniment may be composed of spirits of turpentine four ounces, olive oil and water of ammonia of each two ounces; some fluid preparation of cantharides may be added to an equal proportion of this liniment, if preferred; an ample quantity should be well rubbed on to each side of the centre of the spinal column, from the poll to the setting on of the tail. Some person should be appointed to attend constantly upon the animal, and she should be changed from side to side every four hours, the teats also being repeatedly drawn; in the early periods of the disease she should be induced if possible to partake of plenty of water slightly chilled, but if she will not voluntarily take fluid some infusion of linseed must be made, and a couple of quarts given with the horn every three or four hours. In those cases which have been referred to, where loss of motive power is the only prominent symptom, it will yet be advisable to administer a full dose of cathartics and stimulants and apply the stimulating liniment as before directed: this will prevent the inability to rise being prolonged, as would otherwise be the case, for seven, eight, or more days; bleeding, however, will be altogether inadmissible. In from eight to twelve hours, if the symptoms are unrelieved or the animal has become worse, more restless, or more comatose, as the case may be, it will be advisable to repeat half the dose or more of the cathartic medicine, combined with the same amount of stimulants as before, substituting for the water, as the menstruum for its administration, some por-

tion of linseed infusion. Great care should be observed in the repeated administration of powerful stimulants to prevent their passing into the windpipe, and indeed, if the animal is utterly unable to swallow the medicine when fairly placed in her mouth, it will be better to desist, and either await the effect of that already administered or consign her at once to the butcher; any fæces that may be retained in the rectum should again be removed and some more soap and water injected; no solicitude need be entertained as to the state of the bladder, whether full or empty. Occasionally hoove will be present to a considerable extent; the animal should then be turned over, more especially if she be lying upon her left side; but if the swelling still increase it will be useless to interfere; although it is easy enough to puncture the paunch and evacuate the gas, yet the collapse immediately consequent would be assuredly fatal. The subsequent treatment will be but a continuation of that already laid down, varying the stimulants according to the urgency of the symptoms; the fæces should be removed as often as the rectum is filled, and small quantities of infusion of linseed should be repeatedly horned down the throat. If success attend the treatment, generally in about forty-eight hours, or rather less, purging will commence, and frequently in a few more hours the animal rises. The treatment during the return to convalescence will comprise an allowance as diet of a moderate quantity of hay, and a mixture of dry bran and bruised oats. If the purging be prolonged beyond the second day some bean-meal may be substituted for the bran; the drink should consist of wheat-flour gruel, or, if this is refused, a very limited supply of boiled water; if the purging is excessive, two drams of powdered opium, with two ounces of chalk, and a few drams of carraway-seeds, may be administered once during each day in a small proportion of gruel. In some cases the animal's appetite returns, rumination is re-established, and the secretions and excretions are natural, but she is unable to rise; care should then be taken to turn her over at least once each day, and she should be comfortably bedded up with litter. If eight or nine days elapse in this way it will be necessary to raise her up and sling her on a couple of sacks: often after they have been supported in this manner for an hour or two they will be able to continue standing without further assistance; but if she be unruly in the slings, and bear but little weight upon her legs, she must be lowered down again, and perhaps on the morrow she may be raised with better success; hand-rubbing the legs for several hours will also be attended with benefit in these cases. It is a matter of great importance to the proprietors of cattle if any preventive precautions can be taken against this affection; very limited feeding, both before and after calving, has been

recommended, the abstraction of several quarts of blood a few weeks prior to parturition, the administration of cathartic or febrifuge medicines about the same period, or immediately after parturition; but cows submitted to each of these plans of treatment have yet fallen victims to the disease; neither is it to be expected that owners can submit every beast to such precautionary measures; yet if there be any suspicion of a particular animal, from her having an unusually large udder, or a more dependent belly, with little inclination to move about, the following course of procedure should be adopted. It is *not* advisable to withhold almost all food for the day or two preceding parturition; on the contrary, a fair average quantity should be allowed, but it is equally injudicious to permit the animal to gorge itself to excess. As soon as the animal will partake of it after calving, gruel or chilled water should be furnished *ad libitum*, and a pound or a pound and a half of Epsom salts, with two ounces of nitrate of potash and a few drams of ginger, may be administered about four hours after calving. It is seldom that an animal, after recovery from this disease, will yield quite as much milk as she has done at previous calvings, but frequently, with judicious feeding, the quantity will not be materially lessened; it is also a matter of certainty that there is a liability to the recurrence of the complaint; yet this is not an invariable rule, but in the greater number of cases it will be the interest of the proprietor to part with a beast that has once suffered from an attack.

The next disease in importance to the cattle proprietor (and more especially in a dairy country, where the loss of milk is of only inferior importance to the loss of the animal altogether) is inflammation of the udder, known in many districts by the name of Garget. Heifers and young cows are more especially obnoxious to this complaint, although more aged animals are not exempt. It may arise from external violence inflicted upon the udder in any way, but it generally appears within a short time after calving; hence it is evident that the tendency of an animal, and especially of a young one, to suffer from fever at this time, may be locally determined, and thus be the cause, among other affections, of inflammation of the udder. Exposure to wet and cold, in the open pasture in the early spring-time, is also a frequent cause; persons unaccustomed to or careless in milking may, by their injudicious handling, determine the disease; but the long-received notion, that leaving a small quantity of milk in the udder at each period of milking is a most frequent cause, cannot be satisfactorily maintained, else should the cow that has one or more calves constantly allowed access to her udder be the invariable subject of the disease, whereas these animals are always exempt. It is true that in some of our dairy counties where females are the milkers this

disease is more prevalent, but it may be accounted for from their unsteady and irregular handling in the process of milking. One of the earliest symptoms, but seldom noticed, is a rigor, or shaking fit; stiffness of the hind leg on the side about to become affected will sometimes precede this; the pulse then becomes increased, with heat of horns, dryness of the nasal pad, partial loss of appetite and rumination; generally only one quarter of the udder is first attacked, but occasionally two quarters suffer at the same time, and it will sometimes extend to the whole gland; the affected quarters will be swollen, hot, and painful; the external skin is of a tense and shining appearance; the secretion of milk is lessened in quantity, and altered in quality, being thin and watery; as the local disease progresses it becomes of the consistence of curd, and is with difficulty squeezed out of the teat; ere this the fever will have become mitigated, or in some cases it will be increased, inducing general disturbance of the system, which not unfrequently becomes locally determined to the lungs; in other cases, lumps of various size will be felt in the substance of the udder, matter will form in the centre of these, which will ultimately force a passage externally, occasionally loss of life will supervene from the absorption of some of this pus by the blood-vessels, it being carried throughout the general circulation, and again deposited, in the form of purulent collections, in other parts of the frame, or in some of the viscera. Mortification and death of some portion of the udder is another termination of this disease: the gland itself becomes of a blue, and the diseased quarters of a dark purple colour; softening of its substance and sloughing may take place, or, if it proceed unfavourably, the gangrene may extend to the neighbouring quarters, and, the constitution eventually becoming contaminated, a fatal termination attends the case. The most frequent result, however, is loss of the function of the quarter or quarters, from obliteration of the secretory apparatus, by the process of effusion and deposition consequent upon inflammation; lastly, in some cases, resolution may be accomplished, and a return of healthy function.

The treatment of this disease will always consist in the abstraction of blood when there is much acceleration of pulse, and generally in its earliest stage, if the local affection be at all severe. It is a favourite practice with some to effect this evacuation from the external abdominal or milk vein, as it is commonly called; this practice is decried by others, on the ground that the vein does not return the blood from the substance of the gland; nevertheless it does return to the heart a considerable quantity of blood from the immediate neighbourhood of the udder. The practical rule that may be adopted is, that in all cases where there is present much fever, and general disturbance of the

system, a sufficient quantity of blood should be abstracted from the jugular to produce an impression upon the pulse; but in those cases in which the disease is more confined to the udder itself, from four to six quarts of blood may be drawn from the abdominal vein. Great care should be taken in securing the opening by pin and ligature, as it is liable to be disturbed when the animal lies down, allowing even fatal hæmorrhage; and, indeed, this venesection should not be intrusted to any but a practical operator. From a pound to a pound and a half of Epsom salts should be administered; and if the general inflammatory symptoms run high, some sedative medicines must be given every four or eight hours: these may comprise either opium or digitalis, in dram doses, or the extract of belladonna in two-dram doses, with one dram of emetic tartar; an ounce of the nitric spirits of ether may occasionally be added. But if the symptoms are less severe, two ounces of the nitrate of potash may be added to the cathartic; and some diuretic agents, as the nitre with resin, in the same doses, may be administered every day or every alternate day, as the case may require. In those cases where pus has formed, attention should be paid to keeping up the general tone of the system, especially if the animal be emaciated, or feed delicately; half the quantity of diuretic medicine should be withheld, and ginger and gentian in ounce doses may be substituted. If gangrene commences, to these last must be added the tincture of opium and nitric spirits of ether, in doses of from one to two ounces each. The local treatment should comprise, in the early stages, fomentations of warm water, persisted in for some time, and repeated at least thrice in the day. After the udder has been wiped, no more efficacious agent than goulard water, with a very small quantity of spirits of wine, can be used; with this lotion the skin should be well saturated. The more pressing symptoms having subsided, some stimulating compound should be applied with friction after each fomentation, and perhaps the best is the compound soap liniment, but this must not be used too soon. If suppuration or gangrene appear likely to occur, the liniment generally known as the black or Driffield oil may be used; the receipt for its formation is as follows:—Take of olive oil, 1 pint; spirits of turpentine, 2 ounces; sulphuric acid, 6 drams; mix these together, taking care to leave the cork out of the bottle for some short time afterwards, or the heat evolved will cause it to burst: if the consistence is too thick, it may be warmed a little when about to be applied. Those quarters which are unaffected should be carefully and gently milked, morning and evening; and so long as the secretion from the diseased quarters continues thin, and can be readily abstracted, this should be done, but it is bad practice to be continually forcing the curdled material

through the duct of the teat; on the contrary, it is better not to draw it at all; but if there be much soft dependence about the base of the teat, a lancet should be thrust upwards into the udder—there need be no fear of evil consequences, provided the teat itself be not wounded, and much benefit will be derived from the gradual draining away of milk discoloured with bloody serum. Should pus form in the gland, which will be ascertained by its softness and fluctuation, it will be prudent to make a large, and as much as possible dependent, opening for its evacuation, and the same must be repeated with any fresh collection that may appear: the importance of making a free opening is in the prevention of sinuses or pipes being formed during the process of healing. This last process may be assisted by the daily application of a digestive, and none will answer the purpose better than the black oils. If any considerable proportion of the udder be mortified it may be removed with the knife, the large blood-vessels being secured with a ligature should they be wounded in the operation: as dressing, a solution of the chloride of lime, in the proportion of an ounce to a pint of water, may be alternated with the compound tincture of myrrh; and as the healing process proceeds, the digestive before recommended should be resorted to. Occasionally, one or more quarters will remain hard and swollen when all other symptoms have disappeared, the disease having terminated, as before noticed, in effusion and loss of milk. When this result appears likely to take place, benefit will occasionally be obtained, at an early period, and more or less absorption of the swelling take place, from one or two applications of an ointment composed of half a dram of the biniodide of mercury to an ounce of lard; although not unfrequently this will act as an irritant, and hasten the formation of pus. During this disease the diet should consist of warm or cold bran-mashes, with a few bruised oats and a little hay; roots should generally be avoided; and if it be the early grass season the animal should be taken from the pasture and shut up in the house; but when the fever and constitutional symptoms have disappeared, or when the animal is suffering from discharges from wounds in the udder, some bean or barley flour, mixed with cut hay and clover, or small quantities of bruised oil cake, may be allowed. If the appetite is entirely gone, she must be drenched with oatmeal-gruel, to which, as the case may require, small quantities of sound ale or porter have been added. The water given to the animal should be warmed; this will disincline her to partake of any great quantity, and thus indirectly tend temporarily to check the secretion of milk—a benefit derived, inasmuch as it is of great importance, if possible, to arrest the disease at an early period, so that the functions of the gland may

be unimpaired. No dairy farmer would think of again breeding from an animal that had lost a quarter, but she would be sold or fattened for the butcher: even if the beast have recovered apparently altogether, yet it will be better to get rid of her, for the vessels of the quarter that has once been affected seldom recover their tone, and there is liability to recurrence of the affection; yet, among high-bred stock, where milk is not the object, but the breeding and rearing of calves, an animal of this kind may be kept with safety, especially if she be valuable on account of the superiority of her conformation, &c.

The diseased affections of the teats may next be considered. Sometimes, a few weeks after calving, cracks will appear transversely across their surface, accompanied with discharge, and peeling off of the neighbouring cuticle. The lead liniment, composed of Goulard's extract one part and olive oil four parts, will be a suitable application. There is another affection of the teats, occurring at almost every period, in which the cuticle is elevated in the form of vesicles: these burst, or are ruptured in the act of milking, leaving the exposed cutis extremely sore. Any mild emollient may be applied in these cases; perhaps as effectual an one as any may be made by triturating together lard with cold spring water until it assume a soft consistence. In each of these affections the sore teats should be carefully cleansed with tepid water and a sponge (taking care, however, not to disturb the scabs) before milking; the unguent being applied immediately after milking. The teat should be handled as tenderly as possible during this necessary operation, the cow at the same time being soothed by the voice and manner of the attendant. Sometimes small warts, with thin pedicles or stalks, are found growing from the teat; the most effectual way to get rid of these is to snip them off with scissors, and apply a heated pointed iron lightly to the part whence they are removed: this last operation will prevent the formation of a fistulous opening into the milk duct, an occurrence which will occasionally take place if the denuded surface be not seared. Should the attachment of the wart to the teat be more extended, a small quantity of paste, composed of white arsenic and water, may be applied to the surface; this will cause them to slough out. The removal of warts should only be attempted while the cow is dry. Occasionally, from the cause above referred to, or from some other unrecognised, a fistulous opening will be found to exist into the duct through the side of the teat, and most commonly about its base. If it be near the apex, it is a matter of little consequence; but if otherwise, it is annoying, as the milk flies in every direction but into the pail. These openings are generally incurable; for the application of caustic to their interior, which would cause them to be oblite-

rated, is to be dreaded on account of the probability of its exciting inflammation of the quarter. Modern veterinary surgery has given birth to a plan for closing these openings with some of the various adhesive substances now so much in vogue, such as solutions of gutta-percha or collodion; these substances must be applied with a small soft brush, and as each successive layer gets dry another should be applied, until a sufficient thickness is laid on to suit the views of the operator.

Not unfrequently the flow of milk through one or more of the teats is obstructed by a small moveable tumour or tumours, about the size of peas, descending into the passage. A small metallic probe should be passed up the teat, which will push them back into the udder, and they will often remain there without causing any further inconvenience. If they continue troublesome, it may be advisable to cut down upon them, or slit up the teat, to effect their removal; but there is great fear to be apprehended of a fistulous opening being left, or obliteration of the duct taking place, after these operations. One solitary case occurred to the author of this treatise, of an animal with her second calf (having been milked with the previous one), in whom, although there was an ample secretion of milk, yet all the teats were impervious: a probe could readily be introduced an inch up to their base, but no farther. The abstraction of milk being thus impossible, it was deemed advisable to bleed and physic her; the secretion of milk was thus checked, and she was fattened for slaughter.

The diseases consequent at times upon difficult or abnormal parturition next claim attention. And first, then, of Hysteritis, or inflammation of the womb. When the calf has been forcibly extracted, or much manipulation has been used to facilitate delivery, or after the production of twins, especially if they be dead, the placental membranes having been thrown off, the animal is sometimes attacked with straining, this occurring most frequently to the cow in high condition; violent expulsive efforts are made, small quantities of bloody mucus passing from the vagina; the contents of the bladder are frequently evacuated; she continues in a recumbent position, ever and anon kicking at her belly; mortification of the uterus, and the death of the animal, will too often be the termination of these cases. If the pulse be full and strong, and she have not been excessively exhausted during parturition, four or five quarts of blood should be abstracted from the jugular: a pound of salts, or a pint and a half of linseed oil, with from two to four ounces of the tincture of opium, should be administered; this last may be repeated in half-doses every four hours if the pains continue. Thin oatmeal gruel should be occasionally horned down, but no solid food must be allowed. Her hind parts should be elevated

somewhat more than her fore quarters, and a quart of gruel, to which half an ounce of a watery solution of opium or extract of belladonna has been added, should be gently injected into the rectum. The couples and loins should be frequently fomented, or a fresh sheep-skin may be closely applied, and retained for some time upon them. In urgent cases, a sufficient quantity of mustard, made into a paste with spirits of turpentine, may be well rubbed into the region of the right flank, and for a considerable distance around. Care should be taken to arrest any formation of gas in the paunch; to which end, half-ounce doses of the chlorinated lime may be given in a little cold water. If this be inefficient, the stomach may be punctured with a trochar, as in the ordinary operation for the relief of hoove, and the canula of the instrument allowed to remain. In many cases, particularly in heifers, the state of exhaustion and collapse will from the first be excessive, especially if there has been a prolonged labour. The animal will throw itself flat upon its side, with the head stretched out; occasionally she kicks at her abdomen, the breathing is accelerated, the pulse can hardly be felt, or perhaps not at all. No bleeding must be practised here, but the local fomentations, extending to the shape and udder, must be unremittingly followed up. The liquor ammoniæ acetatis, in eight-ounce doses, with two ounces each of nitric spirits of ether and laudanum, should be administered and repeated every four hours, until the animal become tranquil and lie in a natural position. If the prostration of strength be extreme, carbonate of ammonia, in half-ounce doses, may occasionally be advantageously exhibited, and even from two to three ounces of spirits of turpentine may be tried. Two or three quarts of warm oatmeal gruel, with a pint of sound ale or porter, should be given every four or six hours in the intervals of the medicine; and if she will partake of chilled water, any quantity may be allowed.

Profuse hæmorrhage from the womb, shortly after calving, is never met with; but there is a passive hæmorrhage, which is commonly classed with the disease called Red Water. This latter affection occurs ordinarily in a few days after calving. The urine, when voided, is of a scarlet hue, and, if placed aside to settle, clots will be formed; chemical analysis proves these to be composed of veritable blood. This hæmorrhage occurs from the kidneys; the office of these glands is to separate from the blood passing through them the urine, and from some sympathy with the womb, which lies in their immediate neighbourhood, or from their being unduly excited during the time of parturition, or from that tendency to the localization of fever at this period which has been before adverted to, their secretory function is disordered, and blood itself is separated from the vessels as well as urine.

In many of these cases the general health is unimpaired, but, if there be any fever present, it may be advisable to withdraw a few quarts of blood; whether this be done or not, a brisk saline cathartic should certainly be administered. After its operation, small doses of nitric ether, with spirits of turpentine—say an ounce of each—should be given in some linseed infusion; if there be any straining, an ounce of laudanum may be added. The hæmorrhage continuing unchecked after the lapse of a few days, creosote, in doses of a dram, may be combined with the two first medicines. If the cow be in low condition, some tonics, as gentian-root, ginger, and carraways, should be added, the diet also being of a generous nature. If, on the contrary, she be plethoric, the cathartic may be repeated after an interval of a few days. Some of these cases prove extremely obstinate, and then it will be serviceable to remove the hair from over the loins, and well rub in some counter irritant; the ointment of the biniodide of mercury, in the proportion of one dram to the ounce of lard, will be the best.* Sometimes, after much violence has been used in extracting the calf, or in heifers in whom the genitals are not sufficiently relaxed, the vaginal canal will be much bruised, and even sloughing of some portion of the lining membrane may take place, with a fœtid discharge from the vulva. A portion of tow, saturated with the black oils, should be carried with the hand into the canal, and brought in contact with its parietes; after which, it must be withdrawn. If there be much straining or fever, the treatment recommended in inflammation of the womb should be adopted: if the external labia should be torn, one or more sutures, as may be required, of stout packthread must be introduced to bring the parts in apposition; but the flexible suture wire, invented by Professor Simonds, is a far preferable agent. Inversion of the vaginal canal is sometimes present, the os uteri often presenting at the vulva. This most frequently takes place a few weeks before calving; nevertheless,

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* The disease here alluded to under the term of red-water is of frequent occurrence, as a sequela of parturition, in the eastern counties of England. The attack, which is ushered in by diarrhœa, usually comes on about a fortnight after calving, and very rarely occurs subsequent to the third week. It is attended with much constitutional disturbance, and many animals fall victims to the malady. Although the urine is so changed, both in quality and colour, as to become the most prominent symptom, still it is evident that a disturbance of the digestive and assimilative functions constitutes the essence, as it were, of the disease.

The bleeding recommended by the author is stoutly opposed by many veterinary surgeons, and also by the owners of the animals, from the frequent cases of fatal relapse which quickly succeed the withdrawal of blood. We, however, can speak practically of the good effects attending the removal of a *small quantity* of blood, but the *greatest possible caution* should be exercised in these bleedings, so as to arrest the flow the instant the pulse wavers or is lessened in force. From these remarks it will be evident that none but a veterinary-surgeon should ever venture to bleed an animal suffering from "the red-water of parturition."—T. Beart Simonds.

it is sufficiently often present after parturition to entitle it to notice in this treatise. The most frequently assignable cause is, from its having been protruded for several weeks before parturition; and although, when that act takes place, it is temporarily redrawn within the pelvic cavity, yet the muscular fibres have been so relaxed, that after the swelling consequent upon calving has disappeared it again protrudes. Cows that have had several calves are most commonly the subjects of this lesion. It will be better to fatten and consign them to the butcher; but in the mean time, for the comfort of the animal, and to get rid of a disgusting spectacle, as well as to guard against any possible inversion of the uterus, the metal fastening (which will be described when treating of this last accident) should be placed through the labia. Not unfrequently an animal, a day or two after calving, will be found straining from the rectum, the tail is elevated, and bloody mucus will occasionally be passed per anum. The hand should be passed into the rectum, to ascertain the extent to which the lining membrane is lacerated, and whether sloughing is about to take place. This lesion occurs from the gut being jammed between the calf during its passage and the bones of the sacrum above; heifers more especially are its subjects, from the causes before adverted to. A saline cathartic should be administered, and a digestive applied with the hand, as directed in bruised vagina; the beast should be housed and dieted, and no further ill consequences will ensue. It does happen—but very rarely in the cow—that the rectum becomes inverted, from one to two yards of the gut hanging from the anus to the ground, and it will even be lacerated from the beast treading upon it; the accident occurs during violent efforts made to expel a calf lying in an unnatural position. The knife of the slaughterman had better be immediately put in requisition; all surgical assistance is unavailing. Almost as rare an occurrence is inversion of the bladder; the same causes are in operation to produce this, it taking place before the calf is born; it projects between the labia, in the form of a circumscribed scarlet tumour. If the beast have any meat upon her at all, she also had better be consigned to the butcher. It is recorded that this viscus has been returned, and has remained in its natural position, the animal doing well; but this is certainly the exception to the rule, for it is generally impossible to return it from its being so much bruised, and consequently swollen, during the extraction of the calf, and it is useless to return it before, as the first strong pain would cause its re-inversion. Its extirpation may be attempted with better success: this may be accomplished by tying tightly a strong ligature of packthread around the bladder, and immediately below the ureters or ducts which bring the urine from the

kidneys; the viscus may then be left to slough away. Humanity will dictate that she should, as speedily as possible, be made ready for the butcher, as she will be deprived of the receptacle for the urine, and it will be continually dribbling from the shape, excoriating her thighs and legs, and thus rendering her a somewhat loathsome animal.

Inversion of the uterus is much oftener present; generally it takes place almost immediately after the expulsion of the calf and placenta, but several days will sometimes elapse. In the first instance it is caused by the violent throes of parturition, or from too great force employed in pulling the calf away, especially when it is nearly born. In all cases of assistance afforded to facilitate parturition, when the fore or hind parts of the fœtus (whichever may be coming first) have passed the vulval opening, the force employed should be relaxed, and only sufficient traction used gradually to extricate the remaining portion. When the inversion is of later occurrence, it arises from the womb not having sufficiently contracted after delivery; after pains coming on, the viscus is expelled. Its appearance will at once announce the nature of the accident; indeed, sometimes the placental membranes will be still adherent, but, if not, the cotyledons before described are apparent upon the surface of the protruded portion. In the majority of cases it may be successfully returned, and will be retained. If it be possible to keep the cow standing, this will be more readily accomplished, as she will not strain so much; but if she will lie, an assistant should keep her head as flat as the horns will permit upon the ground, she being turned upon her right side; another assistant should hold a rope, one end of which must be fastened to the left and uppermost hind leg, drawing it forward. This will secure the operator from danger, and allow him free room for his manipulations; the hinder parts should be somewhat elevated by means of straw, &c.

These preliminaries being adjusted, the placenta, if it remain adherent, must be removed by tearing asunder the connecting cotyledons. The uterus itself should then be lightly and carefully cleansed with some warm milk and water, and a clean cloth spread to contain it. The operator, with his right hand, grasps the upper part of the viscus a few inches from the vulval opening, and forces it within. Then introducing the other hand within the vagina, he retains the returned portion, while the right hand is withdrawn to repeat the manœuvre. Thus he proceeds, his assistant gradually advancing the remainder of the inverted portion until the greater part is returned. Finally, he places his doubled right hand against the fundus of the organ, and as he advances it resolutely and steadily onward he gradually withdraws

the left, and generally, when the fundus has repassed the external opening, the viscus suddenly assumes its natural position. The right hand should be passed onwards into the returned womb, fully to ascertain that it has regained its proper position, and after the lapse of a few minutes it may be gradually and gently withdrawn. If there be much straining during the time of operating, thus preventing its facile accomplishment, one or two ounces of landanum may be administered; should the paunch be distended with gas, half an ounce of chlorinated lime may be given in a pint of water, and if this be ineffectual, the paunch may be punctured. The after-treatment should comprise the administration of a saline cathartic, with one or two ounces of laudanum; if the straining be violent, four quarts of blood may be abstracted, and sedatives or restoratives employed according to the presence of irritation or the appearance of gangrene. In all cases sutures of broad tape or white leather should be inserted through the labia by means of a suitable needle, or there have been various forms of truss harness recommended; but these last are open to several strong objections, the difficulty of adjusting the pressure to the vulva, and also of keeping them clean, being the most prominent. Some temporary measures, however, having been taken to prevent the recurrence of the accident, if after several days have elapsed the animal continue straining, with occasional appearance of a red mass at the vulval opening, and no constitutional disturbance, it will be advisable to remove the sutures, and substitute an instrument constructed as follows:—Take two pieces of iron wire, each bent at a right angle thus, . The transverse portions of the wires must be made sufficiently small to pass through a hole punched at the extreme end of each of the lateral portions; another hole must also be made about their middle, through which another piece of wire may pass transversely. Punctures being made in the labia, these transverse wires are inserted through them and the opposite holes in the lateral portions, the instrument being secured by curling round their thin ends with a pair of pliers; or an apparatus somewhat neater, and introduced to notice by Mr. Taylor, veterinary surgeon, of Bury, in Suffolk, consists of a straight piece of brass wire, having three transverse pieces projecting from it, each terminating obtusely by being bent round so as to form a small ring. Punctures being made as before, these cross wires are passed through from side to side; another piece of wire, having a screw at its end, passes through the rings, and the instrument is fixed by the last ring having a thread cut in it, into which the screw works. Either of these instruments may be kept in for any length of time, only occasionally requiring

cleansing. There are cases in which the uterine action is so violent, that the viscus is re-inverted in the pelvic cavity, the sutures preventing its protrusion externally; or the sutures from the pressure may be torn out, and all labour has been in vain. Occasionally, there will exist a rent in the tunics of the uterus itself; at other times the viscus has been inverted for some hours. Possibly many ineffectual attempts have been made to return it, and it has a black or purple appearance, with a distillation of serum from its surface, indications of local gangrene. In these cases it is better to attempt its extirpation. A ligature of stout packthread should be passed around the neck of the uterus, as close as possible to, or just within, the vulval opening, and firmly tied. It may then be again wound once or more around the same place, and again knotted fast. This will prevent hæmorrhage taking place, as the whole of the protruded portion below the ligature should be immediately removed with the knife; the upper portion of the womb, with the ligature, will then retract into the vagina. As the constitutional symptoms will be very similar, so may the after-treatment be guided by that laid down under the head of inflammation of the womb. No attempt should be made to breed again from an animal that has had inversion of this organ.

Retention of the placenta, or cleansing, occurs most frequently when the animal has aborted her young before the ordinary period of parturition; nevertheless it is sometimes retained after natural labour. The membranes hang down from the vulval opening, and a fetid smell exhales from them, increasing in fetor from day to day, and occasionally there will be some straining present. Their retention appears to be dependent partly upon the vitality of the placental cotyledons not being sufficiently impaired, and partly to be owing to the expulsive action of the uterus being defective immediately after the act of parturition, the viscus gradually contracting upon the membranes before they can be thrown off. If the animal be in good condition, or plethoric, it will be requisite to administer the ordinary saline cathartic, viz. 1 lb. of Epsom salts; custom seems to demand some medicament that will determine its action more particularly to the annoyance, and, as practice to some extent will bear this out, from two to three ounces of bruised juniper berries may be added to the cathartic; if, on the other hand, the beast is in low condition, the medicine should consist of the berries with an ounce each of gentian root and carraways in a pint of warm ale and the same quantity of gruel, the cathartic being omitted: about the third day (if they be retained so long) gentle traction may be made with the hand upon them, and not unfrequently in a few hours afterwards they will

be thrown off; but it is not advisable to introduce the hand into the uterus, as it would not be possible to separate each cotyledon from the other, and, if much force be used to the membranes, inordinate straining, and even inversion of the uterus would be liable to occur. Should there be much fetor about the external genitals they may be bathed with a solution of the chlorinated lime in the proportion of one ounce to a pint of water. The ergot of rye has been extolled as being efficacious in this affection, but as it is a drug of much power, and its employment certainly not to be generally recommended or adopted, it will be sufficient to observe that its use should be confined to particular cases, and under the immediate superintendence of a competent medical attendant. One other affection may be noticed, as coming to a certain extent within the limits of this report. Occasionally labour-pains will occur at the ordinary period of parturition, but no fœtus is expelled: these may recur again at periods varying from three weeks to as many months, when the fœtus will be expelled or removed in a more or less putrid state, or perhaps piecemeal; sometimes all the soft parts will be absorbed and removed by the vessels of the uterus, the bones only being expelled per vaginam; lastly, in a few solitary instances the parturient pains never again recur, and the animal will even breed again, but it will be the best plan for the owner to fatten or dispose of her. The removal of the fœtus in these cases does not form the subject of present consideration; and as the after-symptoms (when unfavourable) are as nearly as possible similar to those in inflammation of the womb, so will the treatment in no wise differ.

The Diseases of the Ewe

will form the second part of this Report. And first upon the list comes hysteritis, or inflammation of the womb; this disease is generally consequent upon violence used in the extraction of the fœtal lamb, and to this form the observations will be first confined.

Almost every shepherd considers himself an adept at lambing his ewes, and when, from a false presentation, or twins, or an unusually large sized fœtus, causing protracted parturition, he thinks himself called upon to interfere, he proceeds to extract the lamb at once, without taking into consideration the amount of violence used, and seldom the manner in which he accomplishes his object—that object being, at all hazards, to bring the fœtus away from the mother. In illustration of this it may be noticed, that, while it is not infrequent for cows to be consigned to the butcher because the parties in attendance are unable to

extract the calf, it is very rarely indeed that an ewe is either slaughtered or suffered to die with the lamb in the uterus.

The symptoms after these operations are usually great prostration of strength, the animal is unwilling to rise, in a few hours she begins to breathe quickly, the ears, nose, udder, and legs are cold, the external genitals are swollen and intensely red, there is a bloody serous discharge from the vagina: as the disease progresses the breathing becomes panting, she throws herself prostrate on her side, the paunch is filled with gas, the extremities and udder are deathly cold, the blood-vessels on the surface of this last are filled with congested blood appearing of a dark blue colour, the genitals have now also become cold, and the colour is changed to a purple, the head is drawn back towards the spine, and, after a few convulsive struggles, she expires. Before noticing the treatment of these cases, it will perhaps be advisable again to refer to the duties of the lamber. When an ewe separates herself from the others, and is evidently about to lamb, no long time should elapse before the shepherd satisfies himself if this act have been accomplished; and if it have not, he should, with gentleness, catch her, and ascertain if there be any presentation, that is, if any portion of the lamb has advanced into the vaginal passage; if it has, he should further ascertain if it be coming in a natural position, with the head and fore feet first; if so, he may leave her again to herself, and, provided he have made the examination with care and tenderly, no possible harm can accrue; but if the presentation be a false one he should at once proceed to facilitate delivery, and, if he be inexpert at the matter, no time should be lost in useless manipulations, but the assistance of an experienced operator should be immediately obtained. After delivery, a small quantity of digestive ointment or liniment should be introduced into the cavity of the vagina: however much theoretical deductions would lead to condemnation of this custom, yet practical experience proves the benefit of its adoption; and this may be accounted for from the great tendencey every disturbance of the system in sheep has to assume a typhoid or gangrenous nature, as the case may be.

Almost every shepherd has his particular nostrum to be applied in this way, but no better can be used than the black oils so frequently referred to in this treatise. If great force has been used, or the labour have been long protracted, and there is much consequent exhaustion, half a pint of oatmeal gruel with a gill of sound beer warmed, and from two to four drams of laudanum, should be administered, and repeated at intervals of three or four hours, as the case may require; the same quantities of nitric ether being substituted for the laudanum if the pain is not so violent, and the animal seem to rally a little. But if the

ewe is not much distressed at the onset, two ounces of Epsom salts, with two drams of laudanum, will form the proper medicine, gruel being supplied to her occasionally. When the ewe appears to be recovering she should be shut up in a house for several days, and, if her lamb be alive, it should be returned to her: but if it be dead, and there is no substitute lamb for her, the udder should be drawn with the hand for a few days. The genitals may be dressed occasionally with the digestive, or, if much fetor is present with sloughing, the solution of chlorinated lime may be used. Any lesions of the labia had better be drawn together by suture, although, if they are not very extensive, they usually heal without much deformity. Another and more pure form of hysteritis, although not so frequent as the foregoing, will make its appearance in two or three days after parturition. The ewe is attacked with after-pains and straining, consequent either upon exposure to inclement weather, or from the determination of the accompanying fever of parturition in a local form to the uterus. In the first stages of this complaint the nose is hot and dry, the breathing but little accelerated, the udder is hot, swollen, and tender, the labia are everted and of a scarlet hue, she moves restlessly about and ceases to graze; she is annoyed by the attempts of her lamb to suck, and kicks it away. The symptoms enumerated in the other variety of the disease now rapidly set in, or, from contiguity, the peritoneum, or membrane lining the cavity of the belly, and clothing the womb, becomes inflamed, fluid is effused into the cavity of the belly, she seldom rises unless disturbed, her breathing is heavy, and she appears dull and depressed, death ensuing in two or three days. In many parts of the country this affection is known by the name of redwater, from the colour of the fluid found upon opening the body. The treatment at the commencement of this complaint must be bloodletting; from four to eight ounces, if so much can be obtained, should be abstracted from the facial vein. There are few shepherds but can perform this operation, but there are still fewer who take any care as to the quantity of blood abstracted; the vein being opened, the animal is at once released, and may bleed either more or less, depending upon the operation having been effectually performed or other circumstances. This should not be the plan of procedure. When the vein is made visible, by pressure over the angle of the lower jaw-bone, the opening should be made with a lancet in an oblique direction into the vein, the blade of the lancet being of tolerable size (the shepherd uses his knife, and cuts generally right down to the bone): this will allow the blood to flow more freely than if the opening be made longitudinally, in a direction with the course of the vein; the sheep should be held, pressure being still applied

to the jaw, until such time as the operator considers enough blood has been evacuated, the blood being caught in some suitable vessel. Should the blood continue flowing after the pressure has been abandoned, the edges of the wound may be pinched together with the fingers and a strip of adhesive plaister laid on. The professional attendant will alone be competent to bleed from the jugular, and he will rarely find it necessary to open this vein in preference to the one above described. To resume; after bleeding, the saline purgative with laudanum, as before noticed, should be administered, or, if the bowels be at all relaxed, two ounces of linseed oil with the laudanum should be substituted; the udder, and shape, &c., must be well fomented, and, if there be frequent straining, a dram of the extract of belladonna rubbed down with an ounce of warm water may be injected into the vagina with a suitable syringe. If the sheep obstinately persist in lying down, and the breathing is much hurried, the wool should be clipped from the lower surface of the belly and the flanks up to the udder, and a sufficient quantity of mustard, mixed with spirits of turpentine to a thin consistence, should be well rubbed in. The ewe must be placed in a comfortable house, and, if food is altogether refused, small quantities of thin oatmeal gruel should be occasionally administered, but a few slices of turnips or mangold wurzel may be allowed if she will eat them, and a little barley-flour with cut hay. If the symptoms ameliorate under this treatment she should yet be carefully nursed and sheltered for a few days; but if, on the other hand, symptoms of grangrene, as noticed under the first head, appear, the restorative plan of treatment there recommended must be adopted. Any inordinate flux from the bowels should be endeavoured to be corrected by the administration of chalk in half-ounce doses with the other medicines, always retaining the full doses of laudanum. The rectum will sometimes be bruised, as noticed in the treatise on the cow; it may be known by the straining, with discharge of bloody mucus proceeding from the anus instead of the shape. The constitutional treatment must be adapted to the prevailing symptoms, but the local application of the digestive will be best accomplished by dipping an ordinary candle into the oils and introducing it up the anus, gently moving it about so as to bring it in contact with the parietes of the intestine. Inversion of the rectum and bladder has never been noticed; should either occur, in the first case it would be better at once to cut the animal's throat; in the other, it may be advisable, if the inflammatory symptoms are moderate, to attempt its extirpation by ligature, as in the cow. Inversion of the uterus is, however, not unfrequent of occurrence. The appearance presented is precisely similar to the cow, only on a smaller scale; it happens after long and painful labours, or the

viscus is suddenly inverted when the fœtus is removed by force. It should be returned immediately, and its return will be readily effected; two or three sutures of the stoutest metallic wire being subsequently passed through the labia, and the ewe kept perfectly quiet. It is not always, however, retained, and if it be inverted again and again as soon as returned, or in an inverted state be forced against the sutures, they should be removed, and a strong ligature of packthread passed around the organ as high up in the vagina as possible; it will not be so disgusting a spectacle in the ewe as in the cow, nor will it occasion the ewe so much inconvenience, and it will slough away more readily in the course of a few days if the protruded portion be left hanging from the vagina.

Garget, or inflammation of the udder, is of frequent occurrence in the ewe, but its effects are not so much to be dreaded as in the cow, for the ewe is only wanted to supply sufficient milk for her lamb, and it is seldom that the animal with twins is affected. The only primary source of this complaint is the liability before noticed of the fever always attendant upon parturition becoming localised, or determined to some particular organ. The proximate or determining causes are, lying on wet lairs or pastures, or even on dry ones when the early spring nights are frosty; in fact, a low temperature applied to the newly and highly excited organ. Mechanical injuries are but very rarely the cause of the affection. This usually makes its appearance within a few days after parturition; one-half or even the whole of the udder may be affected—swollen, hot, and painful; the lamb should be removed from her at once. It will be recollected what has been noticed when treating of this disease in the cow, that it is injurious to force the teats much, as, when the disease is fully established, the secretion from the gland is nearly suspended. These remarks will equally obtain here. A dose of physic, from two to three ounces of Epsom salts, with two drams of ginger to insure its purgative action, should be administered. Bleeding, unless some generally unfavourable symptoms, as abdominal pain or hurried breathing, are present, will hardly be called for. There is not the same tolerance or constitutional ability to bear disease in the ewe as in the cow; and on this account also she will be unable to bear the adoption of debilitating remedial measures. Fomentations should be applied to the udder twice daily, persisting in them for some time; the wool should be clipped away, and the goulard water subsequently applied: the ewe must be housed and supplied with some clean soft litter. It is futile to anticipate benefit will accrue from remedial measures in this or any other disease if the animal be still exposed to the same exciting causes; and it is strange that the flockmaster or shepherd is in general so blind to this simple aid to their medical treatment. True, in many cases the

animals are all folded at night, but the shelter of the ailing one should extend even to the day; it will only cause a little extra inconvenience. The diet may consist of turnips, hay, and a few bruised oats. After the operation of the physic, provided the disease be not checked, some medicine of a diuretic and febrifuge nature will be exhibited. From two to four drams of nitre, with two drams of cream of tartar, may be given once each day, dissolved in a few ounces of chilled water. If the swelling of the gland is stayed, and there is less heat, the teats should be drawn twice or thrice in the day, provided there be a secretion of fluid milk; but the lamb should not be too soon returned to her. If, on the other hand, the heat is very great, some portion of the gland will soon be found to soften; pus is forming here; and as soon as a fluid can be distinctly felt, the part should be well laid open; but in the mean time the soap liniment, or, what is better, some black oils, may be diligently rubbed in twice in the day, after fomenting. If the pus evacuated is of a white colour, it should be well squeezed out, and the wound dressed with the digestive (pus in neat stock is always of a more tenacious nature than in man or the horse); but if a fluid or thick grumous matter is discharged, and the wound appear of a livid hue, with fœtor, gangrene is about to or has already commenced; the wound may be washed out with the chloride of lime, and afterwards dressed with the compound tincture of myrrh: the contiguous portions, which may rot or become a dead stinking mass, may, without fear, be removed with the knife, stimulants afterwards being freely applied. These wounds will often heal with great rapidity. If the whole of the udder be a mass of disease, it may be removed by tying a sufficiently stout ligature tightly around its base, close to the surface of the belly. If the constitution suffer, as evidenced by loss of appetite and rumination, with quickened breathing, it is to be feared that the gangrene is extending to the system, and the restorative plan of treatment, under the head of gangrene of the womb, should be resorted to. The ewe that has suffered from any disease of the udder, leaving the slightest hardening or alteration of its structure, should be fed for the butcher; and it is even prudent to draw those that have apparently perfectly recovered, unless it be particularly desired to breed again from them on account of youth or good points. Sore teats with cracks, &c., may be cleansed, and dressed with the simple unguent recommended for the cow; and when these are present, the shepherd must narrowly observe that the lamb sucks as regularly as he should do; for the ewe will be disinclined to suffer pain, and hence double mischief may result—inflammation of the udder from retention of the milk, and an inefficient supply of nutriment to the lamb: in these cases the lamb had better be taken away for a day or two, and suckled from the can; the ewe

will not secrete so much milk when the lamb is absent, and the teats may be drawn twice in the day by the hand.

The placenta is sometimes retained in old and weakly ewes, or after manual assistance has been afforded in the extraction of the fœtus; and decomposition goes on much more rapidly in this case with the ewe than with the cow. Some tonic medicine, composed of a gill of warm beer, with from two to four drams of nitre, two drams of powdered gentian-root, and a little ginger, will form the best cleansing drench; and if the membranes have not come away on the following day, they should be gently pulled with the hand, and often in a few hours they will be expelled; but the hand must on no account be introduced into the vagina. Should symptoms of inflammation or gangrene appear, treat as directed under those heads in affections of the womb.

The last subject to be noticed is retention of the fœtus in the uterus; and this occasionally occurs in the ewe. Sometimes even no parturient pains at all will be observed, but the fœtus can be felt with the hand through the walls of the abdomen; in other cases the throes will come on about the usual period of parturition, but the fœtus will not advance from the womb, and no assistance can be rendered until there is a presentation: these pains gradually abate, and in the majority of cases the ewe will fatten rapidly, the fœtus being found after she is slaughtered, generally in an almost natural state, although if much time has elapsed the process of absorption will to a certain extent have taken place. As a general rule it will be the interest of the proprietor to draw and dispose of all animals that have been in any way affected by disease: the intrinsic value of the ewe will rarely balance against the risk of future loss. A word or two may be said as to the condition of ewes at the lambing season; and observation has confirmed the opinion that, however much a plethoric condition conduces to disease in wethers and stores of all kinds, yet the reverse obtains with the pregnant ewe. The flock that has been badly kept, the animals being poor and lean at the time of parturition, will be the flock in which the greatest losses both of ewes and lambs take place.

XXIV.—*On the Cultivation of Mangold and Carrots in alternate rows upon the Duke of Beaufort's Farm at Badminton.* By PH. PUSEY, M.P.

IN a small pamphlet by Messrs. Proctor, on the management of the turnip-crop,* it is mentioned that Mr. Thompson, steward to the Duke of Beaufort, having observed how much the outer row of mangold-wurzel always exceeds every inner row, determined

* Bristol, 1851.

to make each row, as it were, an outer one, by sowing carrots on every alternate ridge. This happy idea of Mr. Thompson's was so successful that he obtained one quarter more mangold from the land so cropped than from other land adjoining it where every row was planted in the usual manner with mangold. Mr. Thompson described his experiment in the following letter:—

DEAR SIR, Badminton, April 5, 1851.

I have much pleasure in replying to your inquiries regarding our system of growing the roots you saw on the Duke of Beaufort's farm at Dunkirk, especially as to the alternate rows of roots.

From having noticed, that in every case where roots were grown in the usual manner, *the outer row* was much better than the others, I was induced to try several experiments, which resulted in my adopting that system which you saw last autumn, and I believe the same result would follow if tried with swedes or other roots.

The land in October was cleaned and ridged up about twenty-four inches wide, a light dressing of yard manure was placed in the ridges, which was afterwards covered in by turning the ridges back upon it—and in this state it lay till seed time. From the 20th to the end of April the seed was drilled in on the *stale ridge*, with about one hundred and a half of guano and twenty bushels of ashes to the acre. First a row of mangold, then a row of white Belgium carrots; and so on alternately throughout the piece.

The crops were *deeply* horsehoed both before and after thinning, which I consider very essential to both crops, but particularly to the carrots on this brashy land.

You will observe that the land was ridged up only twenty-four inches wide, with the intention of putting every alternate row to carrots; but, on about four acres in the same field (cultivated in exactly the same manner), mangold only was grown where the ridges were thirty inches apart.

On these four acres the crop was about one-third less in weight than upon an equal quantity of land put to mangold with carrots between; and I should say, that the crop of carrots was the best ever grown here, both as regards quality and weight.

I might add, that I have tried the autumn cultivation for swedes on a stale ridge with invariable success on this brashy soil.

Hoping these few remarks may be serviceable to you,

I remain, dear Sir, yours truly,

Mr. Thomas Proctor. JOHN THOMPSON.

After seeing this statement I determined to give the experiment a fair trial, and here also the mangold gave a greater yield on the alternate than on the continuous rows, while the yield of carrots was nearly 8 tons per acre. Mr. Thompson informs me that his plan has been equally successful this year also on the Duke of Beaufort's farm at Badminton. It is certainly a most ingenious contrivance thus to intermix two plants, one with broad leaves that draw, it would seem, much nourishment from the air, the other burrowing deep in the soil for its food.

It realizes curiously the singular Greek proverb that "the half is more than the whole," and may be described shortly as a method of not only improving the mangold crop, but of getting 8 tons of carrots for nothing.

Pusey, November 30, 1851.

XXV.—*Breeding Points of Jersey Cattle.*

I. Scale of Points for Bulls.

The following is the scale of points which guide the Judges of the Royal Jersey Agricultural Society in awarding their Premiums for Male Cattle:—

Article.		*Points.*
1.	Pedigree on male side	1
2.	Pedigree on female side	1
3.	Head, fine and tapering	1
4.	Forehead, broad	1
5.	Cheek, small	1
6.	Throat, clean	1
7.	Muzzle, fine and encircled with a light colour	1
8.	Nostrils, high and open	1
9.	Horns, smooth, crumpled, not too thick at the base and tapering, tipped with black	1
10.	Ears, small and thin	1
11.	Ears, of a deep orange colour within	1
12.	Eye, full and lively	1
13.	Neck, arched, powerful, but not too coarse and heavy	1
14.	Chest, broad and deep	1
15.	Barrel, hooped, broad, and deep	1
16.	Well-ribbed home, having but little space between the last rib and the hip	1
17.	Back, straight, from the withers to the top of the hip	1
18.	Back, straight, from the top of the hips to the setting on of the tail; and the tail at right angles with the back	1
19.	Tail, fine	1
20.	Tail, hanging down to the hocks	1
21.	Hide, mellow and moveable, but not too loose	1
22.	Hide, covered with fine and soft hair	1
23.	Hide, of a good colour	1
24.	Fore-legs, short and straight	1
25.	Fore-arm, large and powerful, swelling and full above the knee, and fine below it.	1
26.	Hind-quarters, from the hock to the point of the rump, long and well filled up	1
27.	Hind legs, short and straight (below the hocks), and bones rather fine	1
28.	Hind legs, squarely placed and not too close together when viewed from behind	1
29.	Hind legs, not to cross in walking	1
30.	Hoofs, small	1
31.	Growth	1
32.	General appearance	1
33.	Condition	1
	Perfection	—33

No prize shall be awarded to a Bull having less than 25 points.

A Bull having obtained 23 points, without Pedigree, shall be allowed to be Branded, but cannot take a prize.

The term "Pedigree" is employed to signify the offspring of a prize, or decorated Male or Female Stock.

The above points were decided by the Special Committee, Col. Le Couteur, Moses Gibaut, Esq., Ph. Le Feuvre, Esq., John Mourant, Esq., Rev. Ch. Marett, Lieut.-General Touzel, John Hume, Esq., and P. C. Patriarche, Esq., and confirmed by the Board of Management of the Royal Jersey Agricultural Society, at a Special Meeting held on June 30, 1849.

JERSEY BULL _ PERFECTION, 33 POINTS.

PEDIGREE, Nos 1 & 2.

Approved by the Annual General Meeting of the Jersey Agricultural and Horticultural Society. 5th January. 1851.

JERSEY COW – PERFECTION, 36 POINTS

PEDIGREE, Nos 1 & 2.

Approved by the Annual General Meeting of the Jersey Agricultural and Horticultural Society, 5th January 1851.

II. Scale of Points for Cows and Heifers.

The following is the scale of points which guide the Judges of the Royal Jersey Agricultural Society in awarding their Premiums for Female Cattle :—

Article.		Points.
1.	Pedigree on male side	1
2.	Pedigree on female side	1
3.	Head, small, fine, and tapering	1
4.	Cheek, small	1
5.	Throat, clean	1
6.	Muzzle, fine and encircled with a light colour	1
7.	Nostrils, high and open	1
8.	Horns, smooth, crumpled, not too thick at the base and tapering, tipped with black	1
9.	Ears, small and thin	1
10.	Ears, of a deep orange colour within	1
11.	Eye, full and placid	1
12.	Neck, straight, fine, and lightly placed on the shoulders	1
13.	Chest, broad and deep	1
14.	Barrel, hooped, broad, and deep	1
15.	Well-ribbed home, having but little space between the last rib and the hip	1
16.	Back, straight from the withers to the top of the hip	1
17.	Back, straight from the top of the hips to the setting on of the tail; and the tail at right angles with the back	1
18.	Tail, fine	1
19.	Tail, hanging down to the hocks	1
20.	Hide, thin and moveable, but not too loose	1
21.	Hide, covered with fine and soft hair	1
22.	Hide, of a good colour	1
23.	Fore-legs, short, straight, and fine	1
24.	Fore-arm, swelling and full above the knee, and fine below it	1
25.	Hind-quarters, from the hock to the point of the rump, long and well filled up	1
26.	Hind-legs, short and straight (below the hocks), and bones rather fine	1
27.	Hind-legs, squarely placed, not too close together when viewed from behind	1
28.	Hind-legs, not to cross in walking	1
29.	Hoofs, small	1
30.	Udder, full in form, *i.e.* well in line with the belly	1
31.	Udder, well up behind	1
32.	Teats, large and squarely placed, being wide apart	1
33.	Milk-veins, very prominent	1
34.	Growth	1
35.	General appearance	1
36.	Condition	1
	Perfection	—36

No prize shall be awarded to a Cow having less than 29 *points.*

No prize shall be awarded to a Heifer having less than 26 *points.*

A Cow having obtained 27 *points, and a Heifer* 24 *points, without Pedigree, shall be allowed to be Branded, but cannot in either case take a prize.*

Three points, viz. Nos. 30, 31, *and* 33, *shall be deducted from the number required for perfection in Heifers; as the Udder and Milk-veins cannot be fully developed: a Heifer, therefore, will be considered to be perfect at* 33 *points.*

The term "Pedigree" is employed to signify the offspring of a prize, or decorated Male or Female Stock.

The above points were approved of and decided by Col. Le Couteur, Moses Gibaut, Esq., Ph. Le Feuvre, Esq., John Mourant, Esq., Rev. Ch. Marett, Lieut.-General Touzel, John Hume, Esq., and P. C. Patriarche, Esq., and confirmed by the Board of Management of the Royal Jersey Agricultural Society, at a Special Meeting held on June 30, 1849.

XXVI.—*On Dried Blood as Manure.* By J. THOMAS WAY, Consulting Chemist to the Society.

THE value of blood as manure has been long known, but many circumstances have combined to prevent it from being employed to any considerable extent.

That blood should be a highly fertilizing substance, we should infer from its composition. I do not propose here to go into any elaborate statement of the analysis of blood, my object being principally to inquire what prospect there is that this valuable substance may be rescued from waste, and systematically thrown into the manure market as a dry and portable manure. But it may be as well to state that ox-blood, according to the analysis of Dr. Playfair, contains from 79 to 82 parts of water, the remaining portion, of from 18 to 21 parts, being, of course, dry matter. In this respect blood very closely resembles flesh, which, according to the same authority, contains 77 parts of water and 23 of dry matter. The ultimate composition of blood and flesh is identical. Omitting the ashes in each case, Dr. Playfair obtained from the analysis of dry blood and dry flesh the following results:—

	Dry Ox-blood.	Dry Ox-flesh.
Carbon	54·35	54·12
Hydrogen . . .	7·50	7·89
Nitrogen . . .	15·76	15·67
Oxygen	22·39	22·32
	100·00	100·00

The proportion of ash in blood is small, not exceeding 5 per cent. on the dry matter. Of this small quantity too fully one-half is common salt; whilst perhaps not more than 20 per cent. of the ash is of any great value to vegetation.

I am inclined, therefore, in speaking of the value of blood as manure, to put aside the mineral matters as too insignificant to require attention, resting its chief merits upon the fact that it is almost pure animal matter, and contains a high per centage of nitrogen. Hitherto comparatively little blood has been prepared in the dry state, and that little has been sold to the makers of prussiate of potash. Some manufacturers, however, are now turning their attention to the possibility of preparing the dried substance on a large scale for manure, and I am in hopes that the value of this substance will be found such as to enable farmers to purchase it at a price high enough both to remunerate and encourage the maker and to secure its application to the purposes of agriculture. From a manufacturer of dry blood I have received from time to time several specimens for analysis, and the results are such as to convince me that blood may be dried on the large scale with perfect success; and that the product obtained may fully come up practically to what might be expected from a knowledge of the composition of the material employed.

The quantity of nitrogen in any specimen of dried blood will be dependent principally on two circumstances: first, the extent to which the blood is dried—because, although sufficiently dry to be portable and pulverulent, it will never be absolutely free from moisture; and secondly, the care and attention bestowed on the evaporation. It is plain that if the blood get carbonized and burnt its value must be proportionately reduced, and, for this reason, open fires should, if possible, be entirely avoided in the heating operations, and steam-cased vessels substituted.

I give now the determination of nitrogen and water in three samples of dried blood, made on the large scale at different times, and sent to me as before mentioned:—

	Water.	Nitrogen.	Ammonia to which the Nitrogen is equal.
Sample No. 1 . .	8·78	13·24	16·07
„ No. 2 . .	7·91	13·58	16·49
„ No. 3 . .	6·19	13·93	16·91

It will be observed that this result is very satisfactory, the proportion of nitrogen being in the last case nearly as high as in average samples of Peruvian guano. The following analyses of other samples will show—what hardly indeed requires demonstration—that in purchasing dried blood it will be necessary that the farmer is assured that *it is dry*. Thus, samples not externally moist were found to contain:—

	Moisture.	Nitrogen.	Equal to Ammonia.
Sample No. 4 . . .	21·81	11·44	13·89
„ No. 5 . . .	29·46	10·45	12·69
„ No. 6 . . .	22·11	11·38	13·82
„ No. 7 . . .	35·43	8·74	10·59

I would not be misunderstood to say that these samples have been offered in the market as dry blood; on the contrary, they have been submitted to me by the maker to determine *how* dry they were, in order that a price might be fixed upon them. It is plain that a farther drying—easily accomplished—will bring them up to the standard of other samples. Altogether, therefore, I think we have a fair chance of getting, before long, a good article of this kind on a practical scale. The *quantity* to be obtained, and the *price* at which it may be purchased, are two other important questions.

From an excellent article on blood, in Morton's 'Cyclopædia of Agriculture,' to which the reader will refer with much advantage to himself, I take the following sentence, with the explanatory note:—"The population of Great Britain at the present moment is about 20 millions; and if we take 75 lbs.* as the average amount of flesh meat consumed by each individual, we have 1,500,000,000 lbs. as the total animal food in one year. And as the blood may be taken to represent at least one-fourteenth of the net weight of an animal, the total weight of the blood of animals slaughtered for food in England will be about 100,000,000 lbs., or 45,000 tons."

This statement refers, of course, to blood in its ordinary state; and as it loses three-fourths of its weight in drying, we should have about 11,000 tons of dried blood as the total quantity available under the very best system of collection and preservation.

How very far the quantity practically obtainable will fall short of this estimate (supposing the calculations given in the extract we have made to be correct), will at once be seen when it is considered that only the blood of those animals that are slaughtered for thickly-populated towns can be at all at the command of the manure dealer, and from this must be further deducted the quantity used for feeding pigs, &c. It often happens,

* "In an Asylum containing, in 1841, on an average 116 persons (10 adults and 106 male and female children), the annual consumption of meat was $104\frac{7}{8}$ lbs.; and in a private family in London, consisting of a gentleman, his wife, ten children, and ten servants, in 1840, the consumption for each person was $370\frac{1}{2}$ lbs. of meat."—*Porter's Progress of the Nation*, p. 591.

too, that the butcher will find the price paid to him for the blood too small to compensate for the trouble and annoyance of keeping it on his premises; and at this time large quantities are daily passed down the sewers of London by those who formerly disposed of it to the collectors.

It is difficult to fix the exact value of dried blood. Supposing it to contain as much nitrogen as the sample No. 3 above described, it would ultimately furnish about 17 per cent. of ammonia. The price of ammonia must not for agricultural use be higher than 6*d.* per lb., which would give the nitrogen value of fully dried blood of the best quality as about 9*l.* 10*s.* per ton; but it is to be remembered that Peruvian guano furnishes not only 17 per cent. of ammonia, but 25 per cent. of phosphate of lime, with other salts, for 9*l.* 10*s.* or 10*l.* per ton, so that ammonia in guano is considerably cheaper than 6*d.* per lb. As a *provisional price*, I think that perhaps from 8*l.* to 9*l.* may safely be given by the agriculturist for genuine *high-dried* blood—I say as a provisional price, because we want experience yet of the precise action exercised respectively by ammoniacal salts and animal matter only in process of decomposition. It may be that the high per centage of carbonaceous matter supplied to the plant at the same time with nitrogen or ammonia by blood, will considerably enhance its fertilizing influence. The farmer's experience will decide ultimately what is the true commercial value of this as of every other manure.

The crop which dried blood will most benefit is wheat. To hops it would prove an excellent manure: indeed, it would not fail to do good to any kind of vegetation if properly employed. A mixture of dried blood and mineral superphosphate of lime would be an admirable drill manure for turnips. Dried blood is likely to be effective on all soils, but especially on light sandy land. In conclusion, I would make a suggestion to manufacturers, based on theoretical considerations. The albumen of blood and the white of egg are of the same composition, and resemble each other in properties. The white of egg, when heated to a temperature of 165° or 170° Fahrenheit, coagulates, and becomes insoluble in water; if, however, it is allowed to dry at a temperature below that named, it becomes a transparent brittle substance, which keeps for any time in its dry state, and is soluble in water. The albumen which is contained in the watery parts of blood equally coagulates with heat, and can equally be dried up without coagulation by a moderate temperature. From its solubility in water, it appears to me that it would be more active as a manure when so dried, than when the coagulation which renders it insoluble is allowed to take place; and I would suggest that some means should be tried with that end in view. I do not refer here to the separation of the clot of blood upon standing, but to the further solidification on heating to the boiling point.

XXVII.—*Report to H.R.H. the President of the Commission for the Exhibition of the Works of Industry of all Nations.*

On Agricultural Implements, Class IX.

By Ph. Pusey, M.P.

(Communicated by the Writer.)

In endeavouring to fulfil the command of your Royal Highness, that each reporter should describe, as to its general state, the branch of industry which falls within his department, my task will lead me not to balance the claims of rival inventions, which are far better shown by the results of the trials given in the words of my colleagues, nor yet to portray their construction, which can hardly be conveyed in words, or even by drawings, but to state plainly, if I am able, the practical effect of agricultural machinery upon the soil or its products; and so, if may be, to further the design of that Exhibition which your Royal Highness purposed not for a gorgeous spectacle only, but, as it has worked itself out, for a focus in which the various nations might combine and compare their scattered rays of realised knowledge.

As our implements are intended not to bring about new conditions of soil, nor to yield new products of any kind, but to do with more certainty and cheapness what had been done hitherto by employing the rude implements of former centuries, certainty and cheapness of action are evidently the standard by which their merits have to be tried, and chiefly the latter property, which forms the superiority of the spinning-jenny over the distaff, namely, economy.

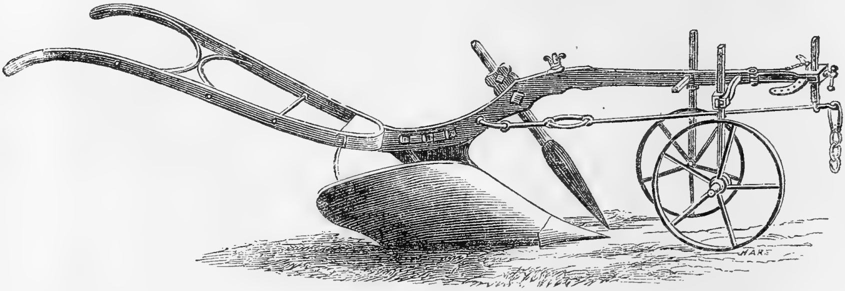
The yearly shows and trials of the Royal Agricultural Society have certainly done more in England for agricultural mechanics within the last ten years than had been attempted anywhere in all former time. Yet though the inventions are many, they may be reduced to a few simple classes: in reviewing those classes, it will be most convenient perhaps to follow the order of cultivation, beginning with the instruments of tillage, and, among these, with the plough.

Instruments of Tillage.

1. *Plough.*

It was found about twelve years ago that in many parts of England ploughs drawn by four horses were still used, while in the same neighbourhood, or even parish, other ploughs were at work equally easy for two horses. The cumbrous plough, resting on a heavy gallows and wheels, had been adapted to the clay soils when those soils were the chief source of corn to the country, and had been handed down from father to son, after the heavy lands had been widely laid down to grazing ground, and the former downs

had become our principal arable land. Not only, however, did these obsolete monuments survive—it was also discovered by Mr. Handley that the inventors of new ploughs, by rejecting the wheels as well as the gallows, had produced, especially in the north, a plough which, though fashionable under the name of swing plough, had little advantage in draught over the ancient one. It was Messrs. Ransome who furnished the modern English plough with two low wheels, and with mould-boards adapted to different soils. Messrs. Howard further improved the mould-board. The mould-board, indeed, which, raising each slice of earth (furrow slice) from its flat position gradually through an upright one, lays it over half inclined on the preceding slice, is the essential acting part of the plough. It should perform this spiral transfer



Howard's Patent Iron Plough.

of a very rough material with an equal pressure both crossways and lengthways. The true shape is founded on mathematical laws, but as, in a somewhat similar case of displacement, that of water by the bow of a yacht, is doubtless best determined by actual trial. The test of perfection in the work of a plough is that the furrow-slice shall lie, after being turned over, in a perfectly straight line, not only unbroken but even uncracked. It is by patient attention to this point that Mr. Busby, with the aid of an excellent farmer, Mr. Outhwaite, produced the beautiful mould-boards of his prize ploughs. This unbroken furrow-slice requires some length of mould-board; and it is urged on the other hand, in behalf of short mould-boards, that they pulverise the soil while they turn it over. Practical farmers, however, know that to pulverise is not the immediate object of ploughing land; but as the length of the English mould-boards surprised foreigners, it may not be useless to state a further reason for that apparently excessive length. Ours also were, in fact, made short and hollow for our new ploughs, until at one of the Royal Agricultural Society's trials all the selected ploughs were brought to a stand in attempting to work a strong clay. The cause of the failure was this: The chief resistance to the horses in ploughing proceeds not from the weight of earth moved, which is insigni-

ficant, nor, unless the ground be unusually baked, from the act of severing the earth, but from two other causes, namely, friction, and, on certain soils, still more from cohesion. Now if the soil contain sharp sand there will be no cohesion; it will work freely off the mould-board, which will be kept bright, and the shorter its surface the less will the friction be. For such soils, therefore, as are common in Scotland short mould-boards may be the best. But most English soils contain so much clay as will adhere to and fill up the hollow of a short mould-board, so that the furrow-slice will have to work not upon an iron surface but upon the most disadvantageous of all surfaces, one of rough loam, and the draught may thus be easily doubled by friction and cohesion together. Hence our English mould-boards have been very properly lengthened, the more properly, I suppose, because the same soil will more often have to be worked in a moist state here than in continental Europe.* Many of the foreign ploughs, it

* Since the above remarks were written, I have received the subjoined report from Baron Mertens; but from my own former experience in dynamometrical trials, I am bound to say that I should not draw from a single summer-trial any inference even as to the *lightness* of a plough in ordinary work, and still less as to its capacity for general work. When land is hard and dry, cleavage is the principal element of resistance; the friction is limited, and the cohesion, of course, null. Hence our English ploughs which seemed the lightest were brought, in a former trial, to a dead stand on moist clay. The American ploughs are very elegant and light, but seem hardly steady enough for breaking up an English clover-ley. The Belgian mould-board is good, though the framework is as unsuited to our workmen as our own would be to theirs.—Ph. P.

"London, July 29, 1851.

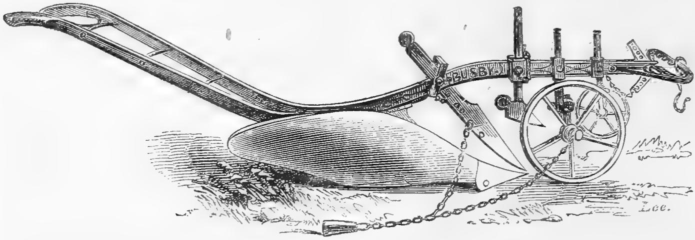
"The trial of the following prize ploughs with Bentall's dynamometer took place on the 25th instant, at Mr. Mechi's farm, near Kelvedon, Essex, before Col. Challoner, Mr. Johnson, and myself. Morin's dynamometer (French) could not be tried, on account of the rain. The trials were attended with great success, as you will perceive by the following results:—

Ploughs.	Name.	Points of Resistance.	Remarks.
1. Belgian	Odeurs	527	Land very hard going up hill, coming down in Ball's plough's furrow.
2. American	Hale and Spear	530	Land hard.
3. English	Busby	540	Land worked well.
4. French	Bodin	546½	
5. Holland	Jenken	550½	
6. Belgian	Delstanche	568	No ploughmen to use them well.
7. English	Howard	569	Hard land.
8. American	Prouty and Mears	579	
9. French	Talbot	580	
10. English	Ball	646	Very hard ground; very good furrow.
11. Ditto	Ransome and May	659	Very hard piece of land.

Baron Mertens d'Ostins. C. B. Challoner.
Baron Mertens, for Mr. Johnson."

should be said, behaved exceedingly well under all disadvantages, and were no doubt better suited than ours for their respective localities.

Ploughing itself is certainly a singular instance of great skill acquired by a body of men who scarcely, as was remarked by Lord Ashburton, receive the credit due to that skill. A good ploughman will set up a pole a quarter of a mile distant or more, and keeping this mark, almost invisible, steadily in his view, will,



Busby's Two-Horse Plough.

on land perfectly smooth, trace up to that goal, until his horses knock it down as they pass on each side, a furrow so true that no eye can detect any divergence from absolute straightness. If one saw for the first time a field of short green clover converted in a few hours into a surface of clean brown soil in regular ribs, it would be regarded as a triumph of art. I mention this, the rather because in speculative writing the plough is sometimes depreciated and the spade is extolled, though this very operation of preparing our wheat land could scarcely be executed at all by the spade, since it is necessary that the existing sward should be perfectly buried. The caution seems more necessary, because, as we have seen in the Exhibition building, ingenious attempts are being made at steam digging, as well as steam ploughing.

The result of the trial of ploughs will be found in the following report of Mr. Shelley.

RESULT OF TRIAL OF PLOUGHS AT PUSEY.

By William Miles, Esq., M.P., and John V. Shelley, Esq.; assisted by Mr. T. P. Outhwaite.

The English and Scotch ploughs, eighteen in number, were put to work in the first instance at a depth not exceeding 5 inches—the land a young clover-ley, in excellent condition for the trial of light-land ploughs. The ploughs consisted of nine 2-wheel, three 1-wheel, and six swing-ploughs. The work of the 2-wheel ploughs was generally good; for the first test, not exceeding 5 inches, we found the following most deserving of commendation in the order in which they are placed:—

No. 1. Ball's.
No. 2. Howard's, marked XX.
No. 3. Howard's, marked XXX.

The same ploughs were then put to work at a depth not less than 7 inches, when we found the following did the work best in the order in which they are placed :—

No. 1. Busby's.
No. 2. Howard's, marked XX.
No. 3. Howard's, marked XXX.

Ball's plough, which at 5 inches appeared No. 1, broke the land too much at the extra depth, owing to the formation of the mould-board pressing too heavily on the furrow. The work done by the whole of the swing-ploughs was moderate, especially that by the Scotch ploughs, which was decidedly bad. The three best ploughs, viz., Mr. Busby's, Mr. Howard's, and Mr. Ball's, were then taken to the heavy land, and were subjected to a very severe test. The work there was satisfactorily completed, and we place the ploughs according to the following order of merit :—

No. 1. Busby's.
No. 2. Howard's.
No. 3. Ball's.

Mr. Howard had one plough only tried on the stiff land. The ploughs were tested as before—first, at not less than 5 inches deep, and then at not less than 7 inches, and the same result appeared at both depths. The objection observed in the plough of Mr. Howard was, that there appeared to be too much curvature in the tail of the mould-board, which caused the land to break up in turning, and a great advantage was thus given to the plough of Mr. Busby: at the same time, the work done by Mr. Howard's plough was very good; that of Mr. Ball's good; but that of Mr. Busby's was superior.

Three 4-horse ploughs were tried in the lighter land at a depth of from 9 to 10 inches; they appeared on that in the following order of merit :—

No. 1. Busby's; No. 2. Hensman's; No. 3. Howard's.

Six Subsoil Ploughs exhibited :—

No. 1. Bentall's; 2. Grey & Son's; 3. Comins'; 4. Coleman's.

In the latter an improved system of adjusting the lever appeared, the construction of which we consider to be good.

In the turn-wrist ploughs we considered that none were exhibited deserving of remark. Lowcock's one-way plough could not be worked, owing to a portion having been lost on the railroad; but having tested it on former occasions, we recommend it as worthy of notice.

The best of the six Belgian Ploughs exhibited was that of Mr. Odeurs, which cut the side clean and left the sole level. Worked steadily, and was easy to hold. In the turn-wrist ploughs of Mr. Vaumael, a new principle of turning at the ends of the land, and of the adjustment of the mould-board, is worthy of consideration. The turn-wrist plough of Mr. Dufour also worked satisfactorily. It is right to observe that Mr. Busby had applied to his plough the moveable nose-piece invented by Messrs. Ransome. Upon the whole, it is considered by the Judges that the working of the ploughs was satisfactory.

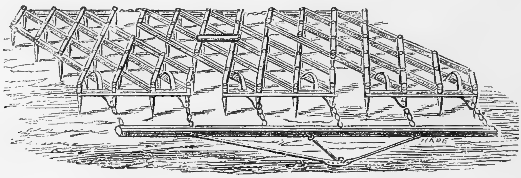
JOHN VILLIERS SHELLEY.

It should be remarked that ploughs suited for common and for deep ploughing distinctly have for some time been separately encouraged by the Royal Agricultural Society. There can be no

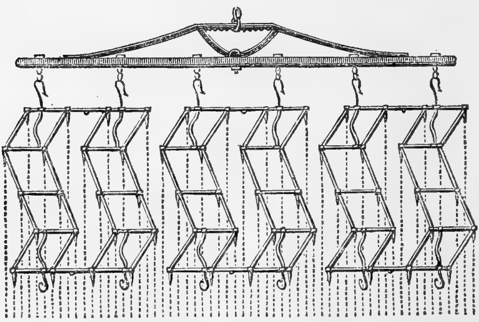
doubt that on most soils it is useful once in four years, when the root crop recurs, to give the land a deep stirring: if that be thought too laborious, the farm should, in each field, get once at least, if only once for all, a thorough disturbance. But a common plough is not suitable for this purpose, since the soil crumbles back into the furrow. One such deep plough, therefore, as Busby's should be kept on most farms, to be worked at leisure in winter with four or even six horses.

2. *Harrow.*

The harrow has been made, I suppose, with square bars, and therefore straight-set teeth, for as many centuries as it has been used, but it is difficult to make the teeth of such a harrow work always in different tracks, although the harrows are dragged from the corner. This imperfection has been remedied within the last few years, in two harrows, to each of which prizes have been awarded. The teeth being set crossways, the harrows themselves can now be drawn straight.



Williams's Patent Iron Harrows.



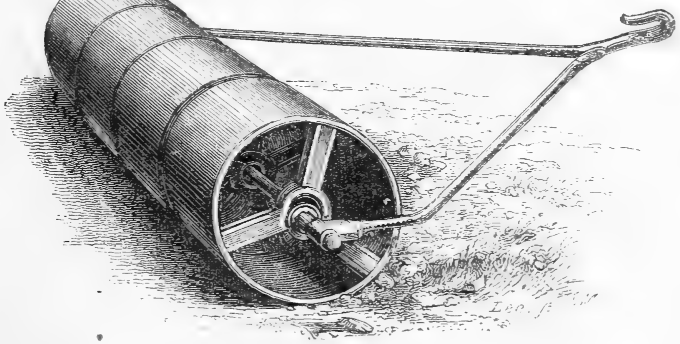
Howard's Harrows.

A third novelty has also been produced and rewarded—Mr. Coleman's expanding harrow. The bars at every point of crossing are united not by a screw, but by a loose pin, on which they work freely. Thus the width of the harrow can be increased or diminished, and the tines, according to the state

of the land, be brought nearer together or spread wider apart, exactly like the mimic soldiers on the child's toy. It is true Mr. Coleman's harrow looks rather cumbrous; but on examination it is found to possess small, almost invisible, wheels, which are easily let down, and serve to move the harrows from one field to another. This is a further advantage, for a set of common iron harrows must first be separated, and even then are troublesome enough to convey.

3. *Rollers.*

Not many years since the landlord was often asked by his tenant for some old tree to convert into a roller. The tree roller, when manufactured, had its framework loaded with rough materials to give it weight. But it soon wore and cracked, so as to produce in a year a most ungainly instrument. Sometimes the tree was manufactured into what was called a cheek-roll, that is to say, a roll without framework, but with an iron peg driven into each end, to which pegs the horse's traces were fastened. We have now very excellent rollers with iron cylinders, which last for ever; but it does seem that for rendering the soil fine their regular form has this disadvantage, that they pass so equally over small clods as merely to press, not to grind them. A more squeezing motion seems to be wanted. Mr. Claes of Belgium exhibited a roller intended for narrow round ridges, but which seems to possess the germ of this very squeezing motion which we require. The roller consists, in its breadth, of four separate rollers of equal size; these do not work on a fixed axle, but contain a central circle of



New Belgian Roller.

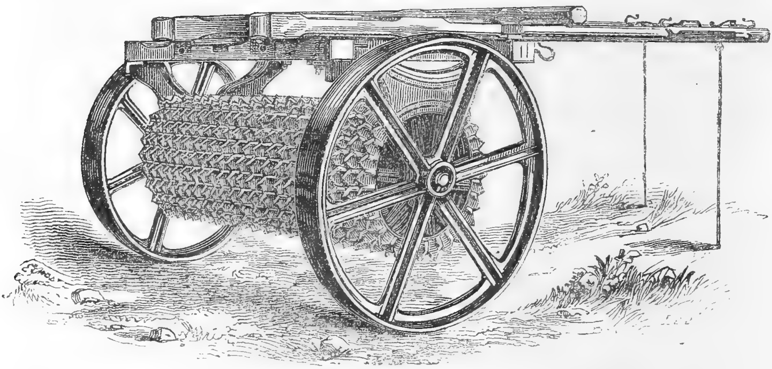
iron, within which the common axle lies for the four rollers to play freely upon.

The common axle rests, in fact, always on the lower surface of the internal circle of the four rolls, which thus move irregularly with the freedom desired.

The roller has, however, been superseded in its function of clodcrusher by the instrument which bears that name, though we still see farmers engaged in the hopeless attempt at breaking, by the alternate use of roller and harrow, clods which refuse to be broken. The barley crop of course suffers thereby in quality as well as in measure.

4. *Clodcrushers. Norwegian Harrow.*

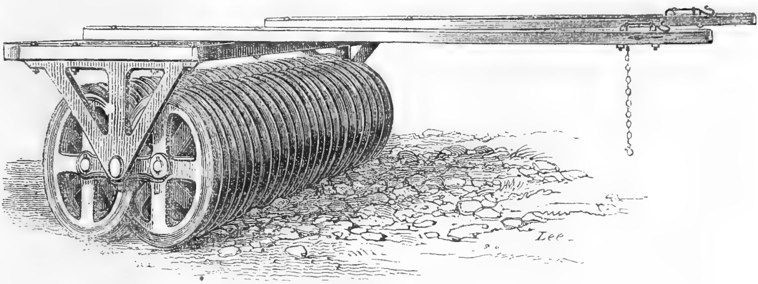
Mr. Crosskill's clodcrusher is well known as one of the most popular of our new inventions. Its principal use is in breaking down turnip-land which has been fed off by sheep in wet weather and afterwards baked by the sun. Notwithstanding its jagged iron



Crosskill's Clodcrusher.

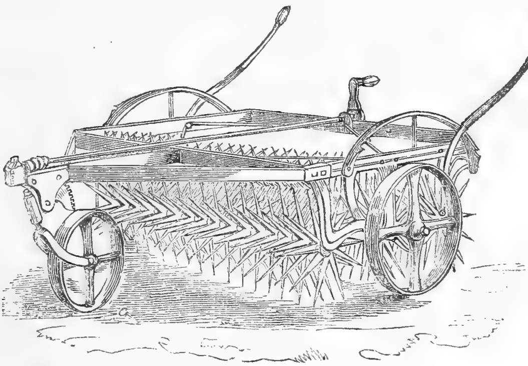
teeth, it has been found, too, the best presser for young wheat in March, when the soil has been swollen and the roots thrown out by alternating frosts and thaws. Thus applied it also arrests the wireworm, and, if it wound the tender blade, the wheat tillers the better. By using it according to its intention, especially in the preparation of barley-land, we may avoid sowing on cloddy ground or save three weeks' delay of the sowing, and in either case may gain at least one quarter of barley per acre, thus paying for our implement in the first season. Mr. Gibson's clodcrusher, now first brought out, is on a different construction, being formed of two rows of very narrow wheels, alternating with each other. Mr. Crosskill's has the defect of clogging when the soil is moist, Mr.

Gibson's of pressing the ground rather tightly: it is between these two weak points that a choice must be made in selecting a clod-



Gibson's Clodcrusher.

crusher. There is a third implement—the Norwegian, or, as it should be called, the Swedish harrow—which neither clogs nor kneads, but then it will not press, and is heavier for the horses. I should not hesitate to choose the clodcrusher if I could afford one such implement only, but from experience in barley sowing should be extremely sorry to be without the Swedish tool also, which has been lately much improved by lengthening its teeth, while its draught has been lightened by one horse in four.



Crosskill's Norwegian Harrow.

5. *Scarifiers, Grubbers, or Cultivators.*

Numerous as are the forms of this implement, and it appears in new forms every year, its full serviceableness has certainly not been yet understood. It has been used accidentally as it were, and not upon system, whereas, if it were used upon system, I have no doubt that, important as are the American Reapers, the Cultivator would ensure to the English farmer upon stock land

advantages quite as great, if not greater, for it would save him nearly one half of the entire labour now bestowed on his ploughing; but to prove this it will be unavoidable to enter somewhat into the detail of actual farming. Indeed our implements must of course be judged not merely by their power of effecting a certain object, but by the usefulness of that object when it has been effected. Thus Kilby's paring plough will peel off the turf from a bowling-green as even as a web of cocoanut matting, yet if that were all, it might serve the gardener, but would not serve the farmer. It does, however, serve the farmer, because it gives one mode of accomplishing a most valuable new process, the autumnal cleaning of wheat stubbles.

In order to prove this great saving, the ordinary course of ploughing on a common stock farm, according to the usual four-course system, must be shortly stated.

After the wheat crop, the land, being full of running couch, is ploughed in the winter, and ploughed again, with other operations, thrice more in the spring, until it appears to be clean, when the turnips are sown. In the next spring it is ploughed by many good farmers *twice* for barley; in order that the sheep-droppings may be well mixed with the soil, and so the growth of the barley be regular. The third crop, clover, being sown with the barley gives a rest to the teams until it is broken up with one ploughing, and the fourth crop, the wheat crop, is sown. The account will stand thus :—

	Ploughings.
Root crop	4
Barley	2
Clover	0
Wheat	1
	7

Now it has been found that if immediately after harvest the wheat land be not ploughed, but pared at a depth of 2 inches only, the couch, the cause of so much labour, is intercepted before it has penetrated the ground, and all that future toil becomes needless. This work is done with the scarifier. The saving of labour is easily calculated, if we only compare the breadth of the scarifier, whichever it be, for there are many of them, with the breadth of the plough. Thus our ploughs make a furrow nearly 9 inches wide, and are drawn by two horses. Coleman's scarifier, one of the best for hard ground, is 5 feet wide (7 times as wide), and is drawn by six horses. These three pair, therefore, will cover as much ground as seven pair at plough, and the labour, accordingly, would not be half of one ploughing. There must afterwards be one good ploughing given to lay up the land for the mellowing effect of the winter's frost. In the spring the land can

be once more stirred with a wider scarifier (Biddle's, $6\frac{1}{2}$ feet wide), which would go deeper, the land being looser, with 4 horses only. As this implement is equal in width to $8\frac{1}{2}$ ploughs, 4 horses would thus be doing the work of 16. The operation will in labour be only a quarter-ploughing. There are saved, besides, in spring, infinite harrowings and rollings, which will defray the expense of drilling the turnips.

The plan of autumn-cleaning is the more valuable because it is a *practice* of actual farmers. When we hear of wheat being grown on alternate portions of the same field every year, such an experiment is highly interesting in a scientific view, yet we feel certain that it cannot become general: but when we know that good farmers are yearly extending the practice of autumn-cleaning upon stock land, we are assured that whatever be its advantages they will be generally available upon land of that character.

Again, with regard to the barley-sowing after turnips, it used to be good farming, as I have said, to plough twice. But in order to save ammonia it is still better to pare the land as quickly as the sheepfold is shifted. This may be done by Kilby's or Bentall's paring-plough, and may be set down as a half-ploughing. The frost mellows the surface, and 4 horses scarifying at seed-time will make it fit for the drill. This last operation may be set down as one-third of a ploughing. We may now examine what saving of labour has been produced by this new class of implements:—

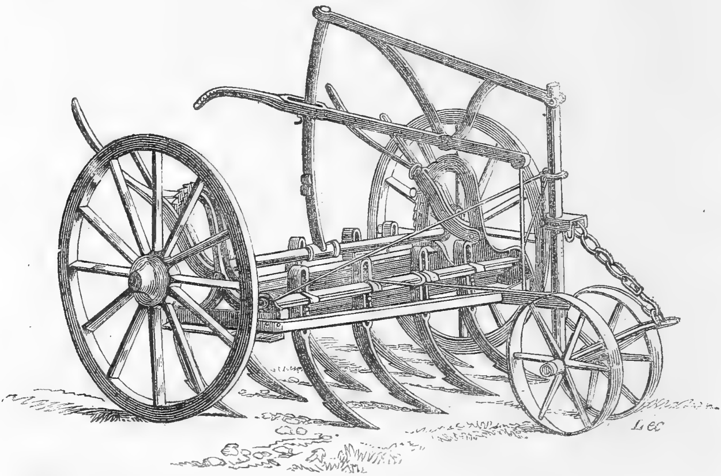
	Old System. Ploughings.		New System. Ploughings.
Roots	4	One scarifying	$\frac{1}{2}$
		One ploughing	1
		One scarifying	$\frac{1}{4}$
Barley	2	One do.	$\frac{1}{2}$
Clover	0	One do.	$\frac{1}{4}$
Wheat	1		1
	7		$3\frac{1}{2}$

Thus it appears that the Cultivators will spare just one half of the horse labour employed on the plough, doing the work, too, as well or better. Adopting the standard of economy as the test of their merit, we find that, if a ploughing be valued at 8*s.*, they can save 7*s.* an acre yearly over the whole of an arable farm. And we may adopt this calculation in their favour more confidently, because (by other means) an equal saving of horse-work can be made at other seasons in other descriptions of work. Some exceptions to this general use of Cultivators will occur of course to every farmer; but the substitution of them for the plough has long been known to many good farmers, though probably it has

not yet been carried out upon system by any one of them to its fullest extent.

These implements were not originally intended for stirring hard ground, but were gradually developed out of the harrow, which was mounted on wheels, with a view to the raising of loose couch out of ploughed ground, a use which autumnal cleaning will soon, it may be hoped, make obsolete.

Of the prize Cultivators, Biddle's by Messrs. Ransome is one of the oldest, and still one of the best. The width gives it great

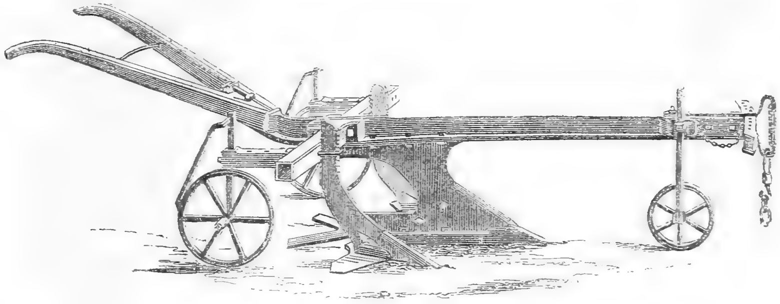


Ransome's Biddle's Scarifier.

steadiness, and its leverage is good, though wearing an awkward appearance. Many attempts have been made to remove this defect, but none so successful as the simple straight levers by which the other prize scarifier, Coleman's, is lifted out of the ground. This is a decided advance, and greatly facilitates the substitution of the scarifier for the plough. Since the trial I have used Coleman's implement, and find it superior to other wide scarifiers: for these implements have hitherto had two defects; they sometimes rise partially out of the ground, and sometimes swerve in their course, thus in each case missing a part of their work. Hence arises often the necessity for dragging them a second time crossways over the same piece of ground. Coleman's scarifier never rises nor swerves, but does its work as true as a plough, doing it therefore once for all. For the mere paring of a very tight surface, however, even Coleman's may be sometimes too broad, and Bentall's narrow one is excellent for that purpose. Its long snout, like a swordfish's horn, is an ingenious device by

Coleman's Cultivator.

which it is enabled to adhere to the land. This cheap implement has also received a prize as a subsoil plough; and though it be a good rule that no implement should do more than one thing, an exception must be clearly made here. Another cheap paring plough, Kilby's, should be mentioned, though not in the Exhibition, because it has the peculiar merit of turning over as well as paring the land.



Bentall's Patent Plough and Broad Share.

In limiting, as has been done above, the number of ploughings, the new system of winter cropping has been passed over, because those extra crops, green rye or tares, winter peas or beans, would more than pay for their extra ploughing. Taking the old system simply, and working it with new tools, we see that common stock land need be ploughed twice only instead of eight times in four years—once after clover, when the green leaves must be turned down, and the dung perhaps be ploughed in, which the plough only can do, once, in order to stir the land deeply for root crops, and lay it rough for the winter frosts. I will venture to add what may appear theoretical—that, if ever steam be successfully employed in cultivation, it will probably be less by ploughing or digging than with an implement like one of these cultivators, because they are able to work so much wider a space as they pass long in their course. From the preparation of land we may now proceed to

II. Implements used in the Cultivation of Crops.

1. *Drills.*

The sower with his seed-lip has almost vanished from southern England, driven out by a complicated machine, the drill, depositing the seed in rows, and drawn by several horses. Here, at least, one would suppose that there must be an increase of expense in the new operation, and, above all, an increase of horse labour; but even here there is, or may be sometimes at least, on the contrary, a diminution. For though we observe only the one seedsman striding over the fallow, he is followed by machinery—the drags and the harrows—which, though simple enough, yet, as they repeatedly traverse the land, run up to a formidable amount the horse-work expended in this primitive method of sowing.

In Mr. Haxton's prize essay upon Oats, which is just published,* we find the following passage :—

Sowing and Harrowing.—The general practice in Scotland is to sow oats broadcast on the winter furrow, and to cover in the seed by two, three, or four harrows coupled together and drawn by as many horses. . . . . Six harrows, three and three together, and drawn by six horses and driven by two men, follow the sower and give a double *stroke* in the direction of the ridges.

Three more strokes, five altogether, suffice, as Mr. Haxton informs us, on friable land, but on an old sward the amount of horse-work expended is really wonderful.

" Old tough lea or wet-ploughed land requires a far greater amount of harrowing than this to bring it into a proper tilth. Two double strokes

* Journal of Royal Agricultural Society of England, Part xxvii. p. 126.

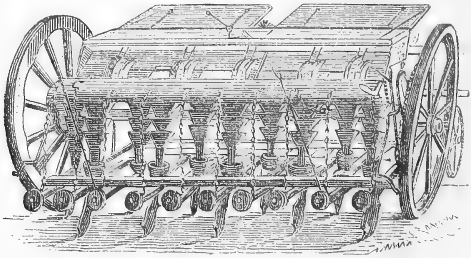
are given in the direction of the ridges to break the furrows and prevent the turf from being torn up by the cross harrowing; and it is seldom that the operation can be properly accomplished with less than six double strokes or twelve harrowings."

Thus a harrow has to be drawn twelve times over the same ground by a horse. If we imagine it to be drawn once by twelve horses we shall see at once the vast saving which would be effected by the Woburn drill, of about the same width with the harrow, drawn by two horses only, yet burying at once most of the seed, and followed, as it has been preceded, by a light harrow—a saving of 8 horses in 12, or 2 horses in 3. This is, however, an extreme case; but we should not be far wrong in saying that by the Woburn drill, which will come presently under our notice, two horses in four, or one half, might be saved to the farmer who has been in the practice of broadcasting.

There is also a saving in seed by the use of the drill; but it is further interesting to observe how the drill dovetails, as it were, with our last class of implements the scarifier. When drilling was unknown, great stress was laid upon so ploughing the land that the furrow edge would stand up sharp at the exact angle of 45 degrees, in order that the harrows catching those edges and crumbling them down might properly cover the seed. No one would have dreamed of sowing corn upon scarified land. Now, on the contrary, the surface may be perfectly smooth; and wheat may be drilled after turnips in winter upon land which has been only breast-ploughed, pared, that is, half an inch deep; for the seed, if drilled, is perfectly covered, and wheat prefers a firm bed. The drill again is indispensable for the use of many new artificial manures, distributing them by special coulters beneath the ground, and covering them with earth, that their excessive strength may not injure the seed, which is deposited above, last of all. The beautiful system of horse-hoeing depends, too, of course, entirely on the use of the drill, which may be regarded as the key of the new system. We ought, then, to regard the whole as a system; not, using the drill, retain ancient courses of ploughing which were meant for the seedsman, nor, on the other hand, fall short in the consequences of the drill—use it, that is, as some farmers do, but with no artificial manure and without a horsehoe to follow.

As to particular drills, there is the general-purpose drill, a very complete implement, capable of drilling, with or without manure, wheat, beans, and turnips at the different intervals suited to those plants respectively, from 2 feet to 7 inches. It comprehends, in fact, two drills, the parts of which are substituted for each other at pleasure; yet admirable as is the implement, one may question whether, as corn seldom requires manure to be sown at the same time, it be not better to buy two drills separate, one for corn, the

other for turnips. One improvement should be used with all drills, as most conducive to the ease of the carter. Formerly drills went



Garrett and Son's Seeding Drill.

upon one pair of wheels, but after they were made to carry a large weight of manure it became hard work for the carter, who, in his zeal to keep the work straight, while leading the thill horse with a stick, steadied the shaft with the other hand, which was almost benumbed when he reached the end of the furrow. A fore-carriage was therefore added by Messrs. Garrett, which is under the command of the carter, who, by a lever, keeps, without exertion, one wheel in the rut down which it previously passed, so that the rows must be perfectly parallel. This steerage is the carter's friend, and the horse's friend too, as it removes a heavy load from his back. Messrs. Hornsby have since adopted, and perhaps improved on, the principle.*

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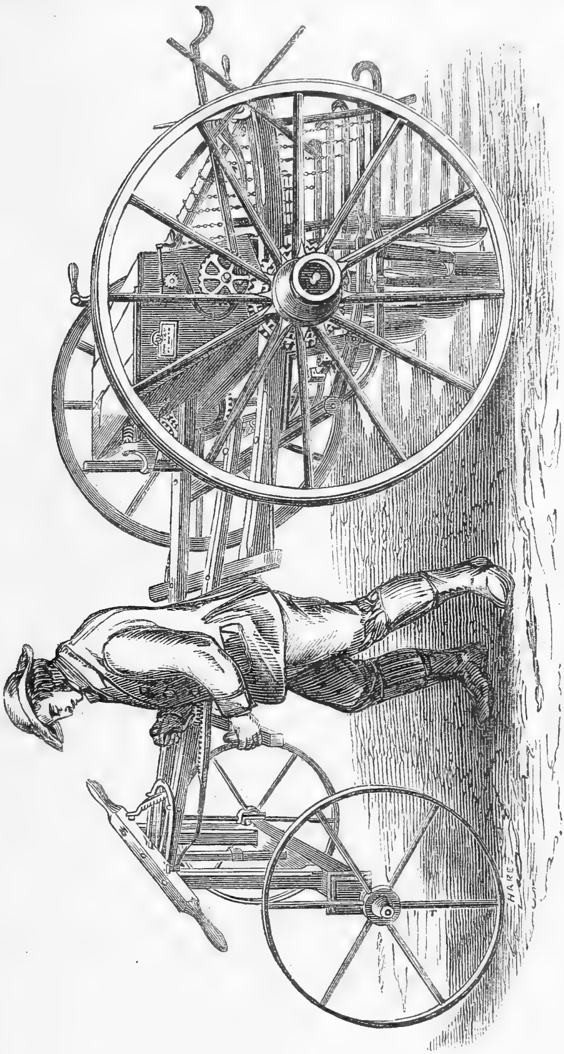
* *Report on Drills.*—Nearly twenty of these implements were selected and sent down to Pusey for trial. Messrs. Hornsby and Son had five drills: their ten-rowed *corn and general purpose* drill was a highly finished and well-made machine, with a recent improvement, patented by them, of India-rubber tubes for conducting the seed down to the channel made by the coulter, which I consider a valuable improvement upon the old plan of a series of cups, made of tin, working one within the other. This drill also has another improvement, of two coulter bars, by which an equal pressure is obtained upon every coulter, and the double-action lever enables the manure to be deposited to any depth, and covered up previous to the seed being deposited. The price of this drill is 44*l.*

A ten-rowed corn and seed drill, peculiarly adapted to drill corn on side hills by a highly finished and ingenious contrivance, of extending or contracting, by means of a screw, two legs, similar to the governor of a steam-engine, attached to the side of the drill, and by which (the drill being hung by or supported on the centre) it can be regulated while in motion. It has also improved slides for regulating the quantity of seed delivered; it has the improved India-rubber tubes and coulter bars, like the former drill; also a very excellent fore steerage, with a rack and pinion attached, by which it can be guided with great exactness. It did its work extremely well: and we awarded it a Medal.

A three-rowed drop drill, which can be used either on ridges or flat ground. It is capable of depositing any pulverized manure at any required distance from 10 to 18 inches, in any given quantities from 10 to 50 bushels per acre. The seed can be deposited with the manure, or the manure covered up with soil and the seed delivered on the drops. The drill economizes manure, and worked very well. Price 24*l.* We awarded it a Medal.

A two-rowed turnip drill on the ridge, which can be made into a three-rowed turnip

The excellence of all Messrs. Hornsby's and Garrett's drills is well known. The Woburn drill of Messrs. Hensman has also

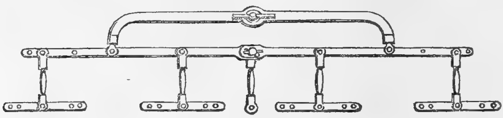


Hornsby's Patent Seed Drill, with Steerage.

drill on the flat, for drilling turnips or mangold-wurzel seed and manure. This drill embraces a variety of improvements—the rollers being made in sections capable of being adapted to a larger or smaller ridge of the proper form to receive the seeds, and the second concave rollers follow, and leave the ridge in a perfect form. The drill is now so perfect, and did its work so well, that we awarded it a Medal.

Messrs. Garrett and Son exhibited their well-known general purpose drill, with the

obtained a medal, and has this peculiarity:—In all other drills the coulters, which distribute the manure or seed, hang from the carriage. In this drill the carriage rests upon the coulters, which are like the irons of skates; it may be said, indeed, to run on four pairs of skates. Hence this drill's power of penetrating hard ground, and of giving a firm bed to the wheat-seed in soft ground. Each drill coulter, however, preserves its independence as when suspended. This self-adjustment is required by the inequality of tilled ground, and is thus obtained: each pair of coulters is fixed to the end of a balance beam, these again to others, and they to a central one. Thus each coulter, in well-poised rank, gives its independent share of support.



Hence this drill is simpler in management than any other, for, resting on its own base like a plough, it is also guided from

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improvement of a simple method of regulating it so as to work on the sides of hills. There is also a slide for the regulation of the feed of the manure, with an index to show the quantity delivered. Price 42*l*. This drill did its work remarkably well; and we considered it entitled to a Medal.

A four-rowed turnip drill on the flat, embracing the improvements of the general-purpose drill, was also put to a severe test with other drills; but, upon the whole, we considered it to do its work a shade better than those brought against it, and we awarded to it a Medal.

A hand-barrow drill—the construction and excellent workmanship exhibited in the implement merited the unqualified approbation of the jury—distributing grass-seeds broadcast in an excellent manner, by means of two compartments in the same box, that the quantities of each may be regulated as desired, the clover and rye grass being mixed in their transit to the ground. We considered it a very useful implement, and recommended it as worthy of a Medal.

Messrs. Ransomes and May, of Ipswich, exhibited a very well constructed drop drill, which did its work very well, and of a very different construction from any of the other drop drills: and, for the ingenuity of contrivance and excellence of workmanship, we awarded it a Medal.

Mr. Busby, of Newton-le-Willows, near Bedale, exhibited a drill which he called a ribbing drill, which is well constructed, very simple, and strong, and does its work extremely well, making a broader seam to lay the corn or seed in, which is considered by many, and especially by foreigners, as a great advantage. Price 14*l*. To which we awarded a Medal.

Messrs. Hensman and Son, Woburn, Bedfordshire, exhibited a self-adjusting steerage corn-drill. This drill varies from the generality of drills, as it is drawn from the centre by whippletrees instead of shafts; and the drill-man behind can steer or direct the drill with the greatest nicety. The corn-box of the drill is entirely self-acting, and delivers the seed equally well going either up or down hill. It is also capable of horse-hoeing, by attaching hoes to the levers, instead of the coulter shares. This implement works very well; and the price from 18*l*. to 20*l*. We awarded it a Medal.

M. Claes, of Belgium, exhibited a nine-rowed, very simple, well-made Belgian drill. It did its work extremely well. The coulters made a broader seam to receive the corn than the generality of English drills; and the harrow which is attached to the

behind like a plough; and any man who can hold the stilts of a plough for a straight furrow can steer this drill with a pair of horses only and reins. Hence, too, its convenience; for if you wish to sow close up to the sheepfold, instead of ordering out a drill and four, as it were in state, you merely keep back one plough from the field.

Hitherto we have been dealing with corn drills intended generally for seed only. In endeavouring to fill up the picture of the point of development at which agricultural mechanism now stands, we come next to turnip drills, in which manure is also distributed as well as seed, generally bones or superphosphate. As is well known, there are two ways of growing turnips, on the ridge and on the flat. In the ridge or Northumberland method the ground is thrown into ridges by a two-sided plough, "a double Tom," and, dung being laid in the intervals, the ridges are split, and the new ridges enfold the dung.

It is on these ridges that Mr. Hornsby's prize drill works, depositing manure-dust and seed, and reducing the ridge, by concave rollers, to a compact rounded form.

The ridge system, however, is most at home under our cool northern and moist western skies—in Northumberland and in

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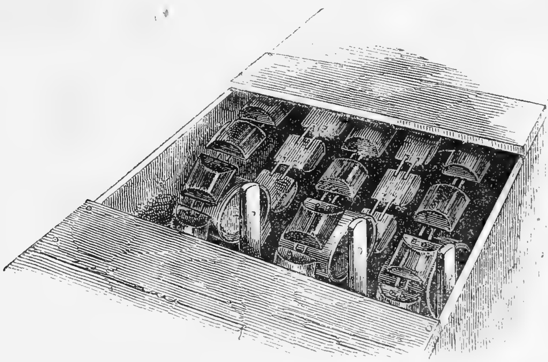
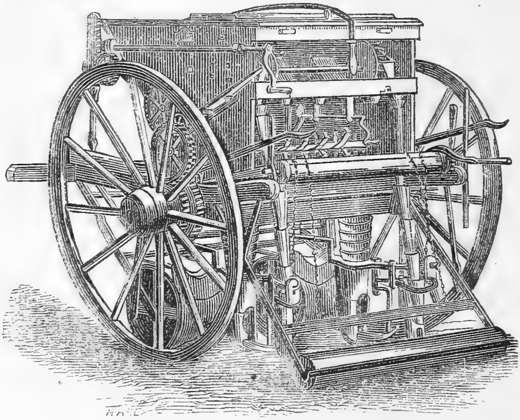
drill covers the seed with fine earth as soon as it is dropped. There is no part of this drill likely to be out of order; it can be worked with one horse; and there appears no part of it that, in case of accident, could not be repaired by a common blacksmith. Price 10*l.* In consequence of its combined merits, simplicity and cheapness, we awarded it a Medal.

Liquid-manure Distributor.—Mr. Reeves and Mr. J. Bratton, of Westbury, exhibited a liquid-manure distributor, which did its work in an extraordinary manner,



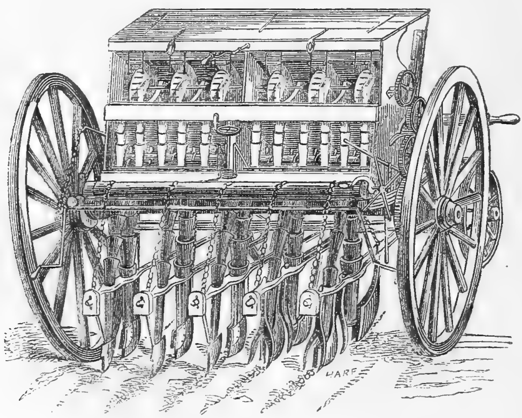
distributing equally manure-water or the thickest sewerage in the most perfect manner. From the construction of the machine it is impossible to clog in the delivery of the thickest slush. It consists of a series of buckets or troughs that are attached to a metal chain or band, and which works round two rollers as the cart goes on, the wheel giving the motive power to the rollers. The price of this admirable water-cart complete is 16*l.* We awarded it Medal.—*C. B. Challoner.*

Lancashire. In our drier districts, as in Lincolnshire and in Berkshire, it is found better with the bulk of the crop, when rain does



Hornsby's Patent Manure Drill.

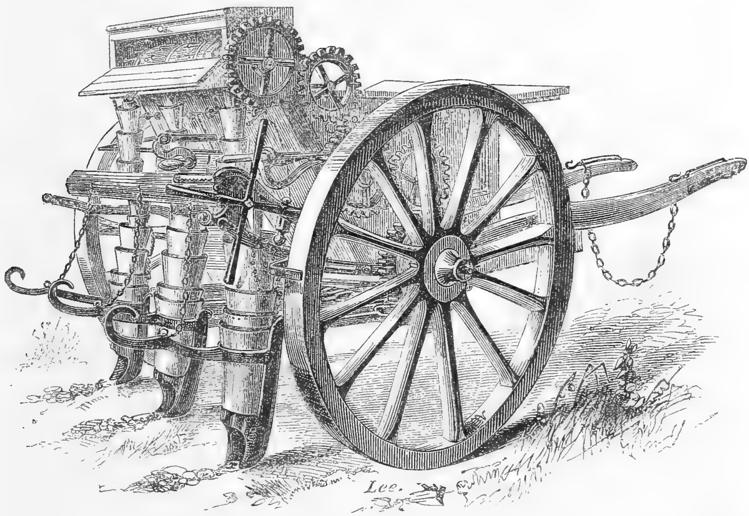
come, to make more expedition. Using a turnip drill, therefore, 6 feet wide, we sow four rows at once with some light manure, and are thus enabled to sweep rapidly over our ground, while the seed finds a damp bed fit for germination before the dust begins once more to fly.



Garrett and Son's Turnip Drill.

Still, however rapid the four-row turnip-drill, south-country farmers are often obliged to wait in July for a soaking shower, waiting indeed often in vain, until it is too late to look for a bulky turnip crop. A south-country farmer, Mr. Chandler, of Market Lavington, Wilts, has produced a machine to deal even with this

defect of our climate. His water-drill pours down each manure coulter the requisite amount of fluid, mixed with powdered manure, and thus brings up the plant from a mere bed of dust. Having used it largely during three years, I may testify to its excellence. Only last July, when my bailiff had ceased turnip-sowing on account of the drought, by directing the use of the water-drill I obtained from this later sowing an earlier and a better show of young plants than from the former one with the dust-drill. Nor is there any increase of expense, if water be within a moderate distance, for we do not use powder-manures alone. They must be mixed with ashes that they may be diffused in the soil. Now the expense and labour of supplying these ashes are equal to the cost of fetching mere water; and, apart from any want of rain, it is found that this method of moist diffusion, dissolving, instead of mingling only, the superphosphate, quickens its action even upon damp ground, and makes a little of it go further.



Chandler's Water Drill.

There is yet one more kind of drill. The common drills economize manure by concentrating it in lines along the rows of the turnip plants. Thus instead of shovelling bones from carts, as was first done in Lincolnshire, at 60 bushels per acre, we came to sow 16 bushels of bones only in lines, or more recently but 3 bushels perhaps of superphosphate, prepared either from bones or from the animal remains of geological ages, among which Liebig told us, and told us truly, to search for our phosphorus.

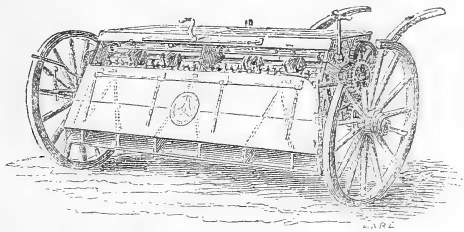
But though turnips are sown in lines, and come up thickly in lines, no sooner are the thriving young plants well marshalled in green array than nineteen in twenty are ruthlessly cut down by the hoe, so that the field appears for a time once more bare. The roots must of course be allowed ample room in the row, but some manure will have been wasted in nourishing the plants doomed to perish. Hence Mr. Hornsby's drop-drill, avoiding this wholesale massacre, is made to drop the seed and the manure, by a second step of mechanic frugality, only at those points in the lines where the plants are intended to stand. Nor are these points in the lines fixed points, for their distance can be varied from 9 inches to 18 inches asunder, and the intervals between the rows can be equally varied from 15 to 30 inches. The dose, again, of mixed manure can be varied from 10 to 50 bushels per acre. Such is the elastic, yet accurate pliability, with which in agriculture mechanism has seconded chemistry. Having now gone through the various kinds of drills—corn or turnip drills, ridge or flat drills, dry or wet, line or drop drills—we may pass to a kindred but entirely new class of implement.

2. *The Top-dresser or Manure-distributor.*

Although, as has been said, wheat is seldom sown with the manure-drill, being usually provided with its chief requisite, nitrogen, through farm-yard dung or through sheepfolding, no plant is so liable as wheat to break down from its first promise, and on inferior soils, whether too light or too heavy, one might almost say that wheat always looks well before Christmas and always looks ill before Lady-day. Our predecessors, to refresh its flagging strength, used to spread soot or pigeon's dung, both containing ammonia, over it, especially on the lower sides of the ridges near the water-furrow, where the plant was perhaps almost killed by the lodgment of rain. But their practice was of course limited by resources so narrow. We having guano and nitrate can deal out liberally the timely supply. But if sown by hand, these very light manures, especially guano, are carried away before their descent by a strong wind; and sometimes when half a gale has been blowing it has seemed to me that I was manuring my neighbour's field quite as much as my own. A manure-distributor was therefore required; and the agricultural meeting at Exeter brought out eight competitors, the winner being Mr. Holmes's of Norwich.

I rejoice to find that we have not only a good invention here, but that it is being actively used. The machine, new as it is, and involving a new outlay for artificial manure, is employed very largely in the western division of Norfolk—the classic ground of

improvement—for distributing a small quantity, such as 3 bushels per acre, of guano or nitrate of soda, or a larger quantity of superphosphate and rape-cake on wheat in the spring of the year. This fact deserves the more to be known, because the convincing argument for any agricultural change is that it has become a *practice* somewhere or other, an argument that answers where reasoning fails. The other argument—that, namely, founded on quick return—is also not wanting, as it has lately been shown that nitrate so applied on poor land will sometimes yield double its own value—near a quarter of wheat—at a cost of 20*s.* per acre.



Holmes's Manure-sowing Machine.

It is curious, indeed, that this very cheap and simple machine is on some soils superseding the more costly and intricate drill. In the words of Mr. Holmes, its inventor,—

They were used very much last turnip-sowing season, and considerably more this season, for sowing manure (rape-cake, malt-coombs, and guano, about 8 or 10 bushels per acre, and in some instances as much as 20 bushels to the acre, when a quantity of burnt earth or ashes are mixed) into the furrows of the ridged turnip-land, at 24, 26, and 27 inches apart. The ridges are then turned over on to the manure by the double-breasted plough, and the manure is covered sufficiently out of the way of the seed, although distributed equally around; so that, instead of striking immediately into the whole body of manure—as is the case when drilled in with the manure—it catches it gradually in its different stages of growth.

This plan proved highly satisfactory to all those who tried it last season, which has induced many others to pursue the same course this season, not only as regards the crops themselves, but also in the labour required to put the crop in. Our manure distributor will cover 3 or 4 furrows at 27 inches apart, if required, and is worked with one horse. It is followed by a light drill expressly for turnips and mangold-wurzel, which is also worked by one horse. Thus it will readily be seen that a great saving of horse-labour was effected by the use of the distributor in the place of the drill.

This saving of horse-work is indeed great, but it must not be disguised that there is inconsistency between the principle of general diffusion here recommended and the concentration which is the aim of the drop-drill. Each method in fact has its merits for different purposes,—concentration for pushing the young plant, extension for feeding it in its later stages. The question, like

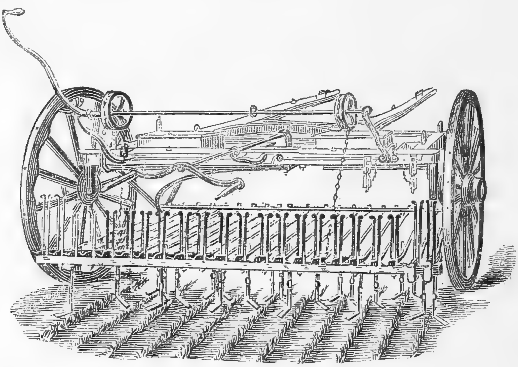
many others, must be decided by longer experience; but the most perfect method would probably be the combination of both plans. To return to our present subject, the young growing wheat, it may not only be revived in spring by additional food, but is usually, on light land, settled down in its bed by

3. *Press-rolls.*

On some soils, especially the calcareous, the ground alternately frozen and thawed in winter throws the roots of the wheat plant almost out on the surface. For this mischief and that of the wireworm flocks of sheep were once driven over the wheat; but we have long had the well-known wheel-roll, and, as has been said, Crosskill's clod-crusher is a still better presser when it can be used, but is not a perfect substitute, as it requires the land to be drier. The new clod-crusher, however (Gibson's), must serve, I suppose, for both purposes equally well.

4. *Horse-hoes.*

Machinery can do but one thing more for the growing crop. The hoe not only clears away a host of young weeds, but, by loosening the crusted surface, admits the air and stimulates the growth of the true crop. Even vineyards are thus found to be relieved during long drought, and hence it is said that the iron should be always between the rows of our root-crops. Ridged root-crops have been long hoed by a single horse, one row at a time. Garrett's horse-hoe cleans four rows at once of turnips, six of beans,



Garrett and Son's Patent Horse-hoe.

nine of wheat. To hoe wheat thus is a delicate operation: to hoe even turnips so, when their lines are but just distinguishable, or again when the leaves almost meet, requires not only a first-rate

implement, but a steady hand and cool head to steer it. This tool will stand well the test of economy, for it will go over ten acres a day easily, with two horses (sometimes one), a man, and a boy, at a cost of, say 10 shillings. The work could certainly not be done otherwise for less than two shillings an acre, 20 shillings altogether, even if you could find hands to do it, in harvest-time. This estimate accords, I find, with the report of the Judges at the York Meeting, practical farmers, who thus speak of the implement:—"The work done by it is far superior to any hand-hoeing: it can also be done for less than half the cost: indeed, so highly do we value it, that we think no farmer can farm as he ought without it." The crops, after hoeing, soon cover the ground, and are thus beyond man's interference until time, the ripener, summons him to the operations of harvest.

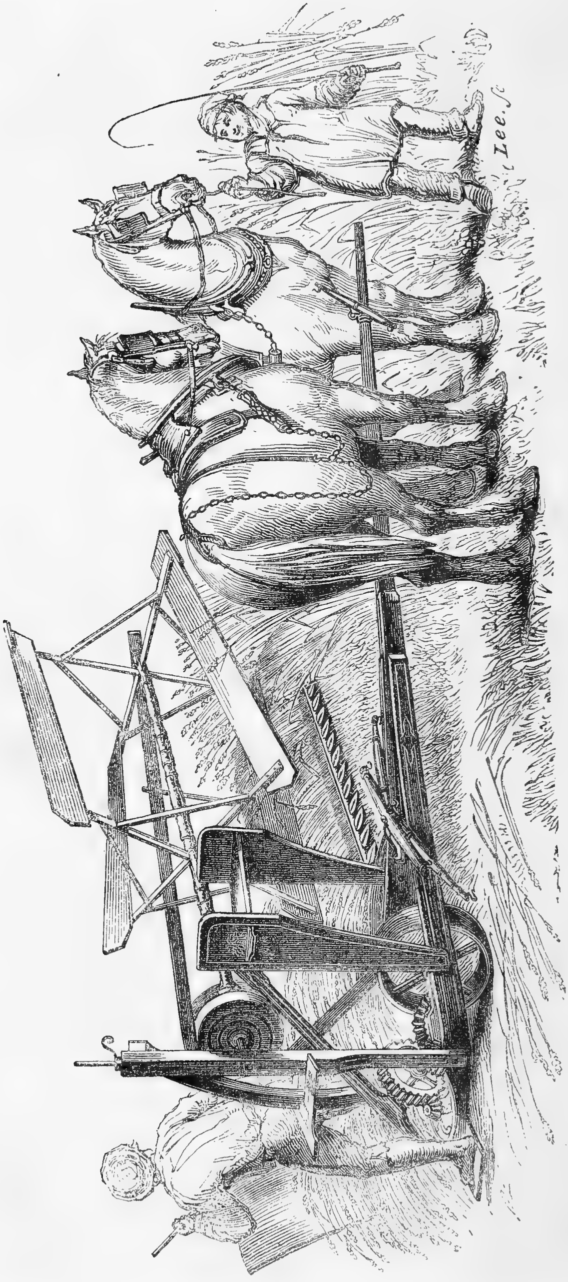
III. Harvesting Implements.

1. *Reaping-Machine.*

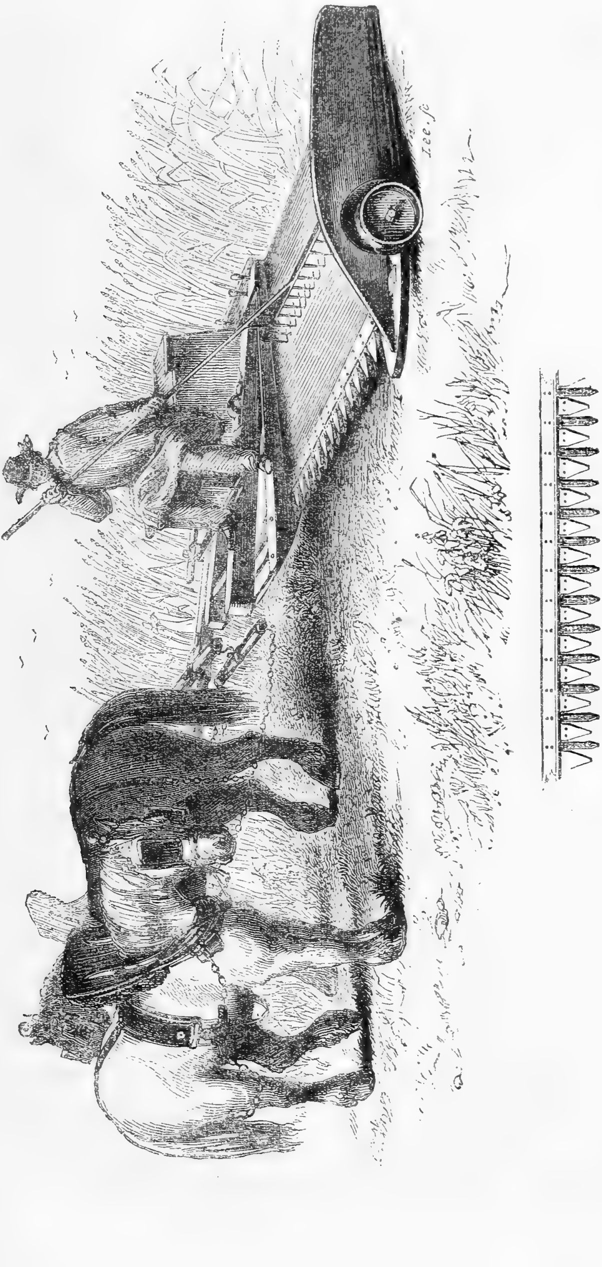
At the opening of this century it was thought that a successful reaping-machine had been invented; and a reward was voted by Parliament to its author. The machine was employed here and abroad, but, from its intricacy, fell into disuse. Another has been lately devised in one of our colonies, which cuts off the heads of the corn, but leaves the straw standing, a fatal defect in an old-settled country, where the growth of corn is forced by the application of dung. Our farmers may well, therefore, have been astonished by an American implement which not only reaped their wheat but performed the work with the neatness and certainty of an old and perfect machine. Its novelty of action reminded one of seeing the first engine run on the Liverpool and Manchester Railway in 1830. Its perfection depended on its being new only in England, but in America the result of repeated disappointments and untired perseverance. The United States Patent Commissioner says of Mr. M'Cormick's reaping-machine:—

> "In agriculture it is, in my view, as important, as a labour-saving device, as the spinning-jenny and power-loom in manufactures. It is one of those great and valuable inventions which commence a new era in the progress of improvement, and whose beneficial influence is felt in all coming time."

Besides difficulties common to all inventions, the machine could be tested but for two or three weeks in each year. When a defect was discovered, before the remedy was applied to the instrument the harvest was over, and the new form had to wait a whole year for its trial, when some fresh failure required a fresh year's postponement of final success. It seems right to put on record Mr.



M'Cormick's American Reaping Machine.



Hussey's American Reaping Machine and Cutting Part.

M'Cormick's own account of his progress, or some extracts at least from a statement written by him at my request:—

"My father was a farmer in the county of Rockbridge, State of Virginia, United States. He made an experiment in cutting grain, in the year 1816, by a number of cylinders standing perpendicularly. Another experiment of the same kind was made by my father in the harvest of 1831, which satisfied my father to abandon it. Thereupon my attention was directed to the subject, and the same harvest I invented and put in operation, in cutting late oats on the farm of John Steele, adjoining my father's, those parts of my present reaper called the platform for receiving the corn, a straight blade taking effect on the corn, supported by stationary fingers over the edge, and a reel to gather the corn, which last, however, I found had been used before, though not in the same combination.

"Although these parts constituted the foundation of the present machine, I found in practice innumerable difficulties, being limited also to a few weeks in each year, during the harvest, for experimenting, so that my first patent for the reaper was granted June 24th, 1834. During this interval *I was often advised by my father and family to abandon it and pursue my regular business, as likely to be more profitable, he having given me a farm.* No machines were sold until 1840, and I may say that they were not of much practical value until the improvements of my second patent, 1845.

"These improvements consist in reversing the angle of the sickle-teeth alternately—the improved form of the fingers to hold up the corn, &c.—an iron case to preserve the sickle from clogging—and a better mode of separating the standing corn to be cut. Up to this period nothing but loss of time and money resulted from my efforts. The sale has since steadily increased, and is now more than a thousand yearly."

One merit of the machine consists in the extreme simplicity of its cutting part—a straight saw, vibrating rapidly right and left. The teeth, however, incline alternately in each direction, so that at each vibration half of them are inclined in the direction of the motion, as is shown in the diagram of a portion of the saw.

As to the practical working of the Reaper, two horses drew it at the trial very easily round the outside of the crop until they finished in the centre, showing that they could cut easily fifteen acres in ten hours. One man drives sitting, and another stands on the machine to rake. It is hard work for him, and the men ought sometimes to change places. The straw left behind at the trial was cut very regularly—lower than by reaping, but higher than by fagging. The inventor stated that he had a machine which would cut it two inches lower. This is the point, I should say, to attend to, especially for autumn cleaning. Though it seems superfluous to bring this machine to the test of economy, we may estimate the present cost of cutting fifteen acres of wheat, at an average of 9*s.* an acre, to be 6*l.* 15*s.* Deduct, for horses and men 10*s.* 3*d.*, and for binding 2*s.* 6*d.* per acre; the account will stand thus:—

Average cost of reaping 15 acres, 9*s*. - -		£6 15 0
Horses and men for Reaper - -	£0 10 0	
Binding 15 acres, 2*s*. 6*d*. - -	1 17 6	
		2 7 6
Saving per acre, 5*s*. 10*d*. - - - - -		£4 7 6

The saving in wages, however, would of course be an imperfect test of the Reaper's merits, since in bad seasons and late districts it may often enable the farmer to save the crop.

Since this statement was written fresh trials have been made of Mr. M'Cormick's Reaper, as also of one by Mr. Hussey; and as the award under the Commission has been called in question, it is right that some statement should be made on the subject. In the first trial at Tiptree Hall, Mr. M'Cormick's Reaper worked well, the other did not act at all. As the corn, however, was then green, it was thought right to make further trial, and special leave was obtained from the Council of Chairmen to give *two* Council medals—one to each Reaper—if, on further trial, their respective performances should be found to deserve one. The object in our second trial was not to decide which was the best implement, but whether either or both were sufficiently good to receive the Council medal. Mr. M'Cormick's in this trial worked—as it has since worked at Cirencester College and elsewhere—to the admiration of practical farmers, and therefore received a Council medal. Mr. Hussey's sometimes became clogged, as in the former trial at Tiptree, and therefore could not possibly obtain that distinction.

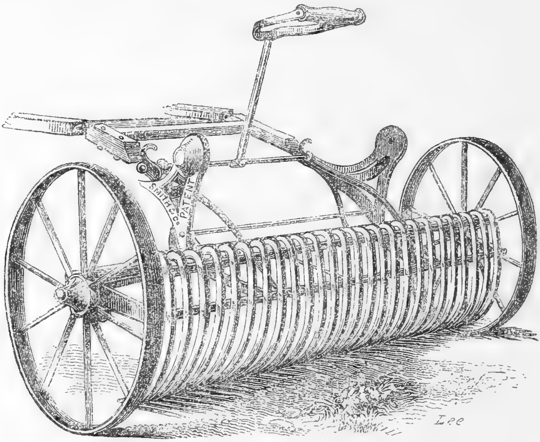
Further trials, however, have since been made by other parties elsewhere, in which Mr. Hussey's machine worked well; and one of our colleagues, Mr. Thompson, informs me that it has been used for a week by a practical farmer on his own farm, who was perfectly satisfied. Its inventor states that at the trials for the Commission the failure arose from a mal-adjustment; and Mr. Thompson informs me that at one of the subsequent trials a similar mal-adjustment impeded its action, until Mr. Hussey arrived to set it right. I am bound, then, to express my own individual opinion that the merits of the machine are such as entitle it to a Council medal, and my regret that it should be formally disqualified to receive one.

We have, then, two good American reaping-machines. Their respective merits time will discover: but there is one caution which applies to the introduction of both into England. They both cut by a sidelong vibration, the frequency of which must be determined by the number of straws to be cut in passing over a given space. Now, as the acreable yield of England nearly

doubles that of America, our straw, it is probable, stands much thicker than in the crops these Reapers have been accustomed to deal with, so that both implements when applied to heavy crops must be adapted to the superior farming they will have to encounter. At present we only know that M'Cormick's machine is best for barley and oats, where not intended to be bound up in sheaf; Hussey's for corn laid by the weather or standing upon steep ridges. Mr. Hussey's can cut rushes, as was shown at Windsor Park. Mr. M'Cormick's has received a prize this autumn in the United States for cutting prairie grass, competing then with two others.

2. *Horse-rakes.*

These are very neat implements, nearly 8 feet wide, running on low wheels, drawn by one horse rapidly between the rows of

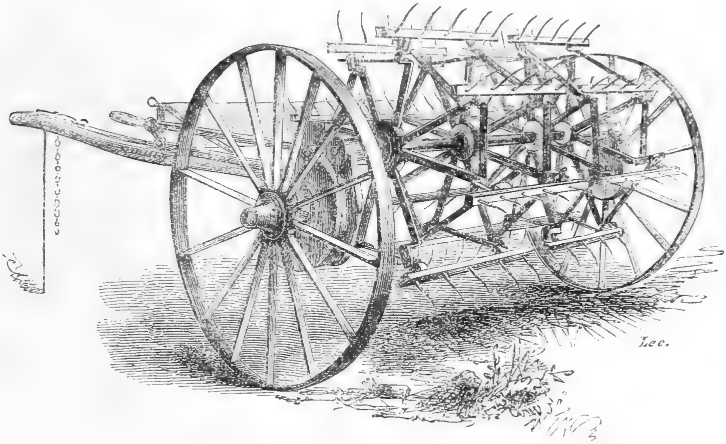


Smith's Horse-rake.

cocked barley, oats, or hay, and tipped from time to time, while they move on, by a man who follows. One of them must do the work of 10 or 15 women. They are common in many counties, yet in others unknown, or, when made known, not adopted.

3. *Hay-makers.*

Every one has seen these machines tossing the hay high above them : instead of this rapid action, if the movement of the frame be reversed, they gently stir the grass without lifting it from the ground. The saving of labour must be as great as with the horse-rake, and the work is far better done.



Hay-maker.

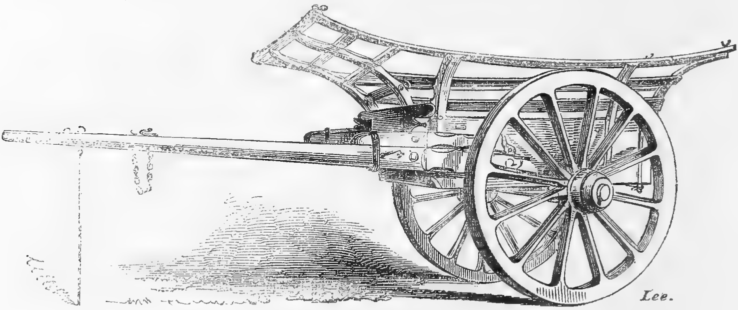
4. *One-horse Carts.*

It is proved beyond question that the Scotch and Northumbrian farmers, by using one-horse carts, save one half of the horses which south-country farmers still string on to their three-horse waggons and three-horse dung-carts, or dung-pots, as they are called. The said three-horse waggons and dung-pots would also cost nearly three times as much original outlay. Few, I suppose, if any, farmers *buy* these expensive luxuries now; though it is wonderful they should keep them; for last year, at Grantham, in a public trial, *five* horses with five carts were matched against five waggons with *ten* horses, and the five horses beat the ten by two loads. It appears that some of our one-horse carts, not being well-made, carry the corn less steadily than the waggons; but this last defence of the primitive waggon is broken down by the curved form which Mr. Busby has given his harvest rails, as is well explained by Mr. Thompson, of Moat Hall, a high authority on these matters, in the following interesting report:—

Carts and Waggons.—The Jurors appointed to examine these classes of implements were considerably influenced in their selection by the opinion that really good *carts* ought to be capable of easy adaptation to all the kinds of work for which agricultural wheel-carriages are required, thus rendering waggons unnecessary. The great majority of carts are, however, ill adapted for harvest work, and this is, no doubt, one reason why such slow progress has been made in substituting light carts for waggons. It may therefore be useful to mention the leading points which ought to be kept in view in the construction of harvest carts, or harvest frames adapted for common carts.

When a load of any height, technically termed a top load, is borne upon one pair of wheels instead of two, it is exposed to much more violent

trials of its powers of cohesion. Every slight alteration of position of the horse which elevates or depresses the shafts of a cart, gives a tendency to the load to slide off either before or behind, which is not the case in a waggon, where no part of the weight rests on the horse's back. If, therefore, as is commonly the case, the harvest frame consists of two or three horizontal and parallel bars, it is found requisite to take small loads, or to bind the load very firmly together with ropes, either of which expedients causes a waste of time, which can ill be spared during harvest; and in spite of such precautions accidents frequently occur. To remedy this fault, some makers have constructed harvest frames with one bar only at the front and back, strengthened by iron stays, as is the case in Morton's harvest cart, exhibited by Messrs. Stratton. This is a considerable improvement upon the two or three bars above-mentioned, inasmuch as the sheaves are bent over the single bar by the weight of the load, and thus obtain a firmer hold; but the desired object is more surely and efficiently obtained by the harvest frame attached to Busby's cart, where the ends and sides all slope towards the body, so as to condense the load by the motion of the cart. The fact that raised ends have a tendency to condense the load was first pointed out by the judges of carts at the Norwich Show of the Royal Agricultural Society in 1849; and in Mr. Busby's cart these suggestions have not only been adopted, but improved upon, by raising the sides as well as the ends.

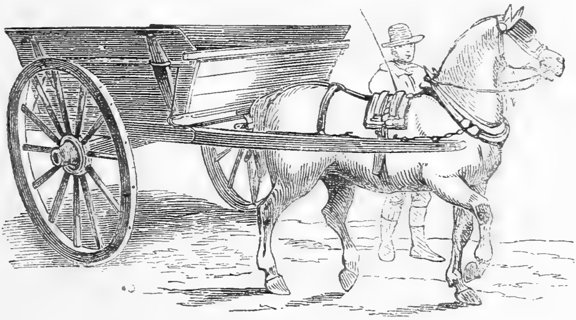


Busby's Cart.

Another important point is, that carts should be low, not only for the sake of diminishing the labour of loading, but to lower the centre of gravity of the load, and thereby lessen the great inequality of pressure on the horse which is experienced in high carts when going up or down hill. It also diminishes the danger of an upset in rough ground or on a hillside. So long, however, as the shafts of carts were attached in the ordinary way, it was found that when carts were much lowered, a slanting direction was given to the shafts, which caused a top load to slide backwards; and this tendency it was scarcely possible to counteract when going up a steep hill. The mode of attaching the shafts observed in Busby's cart, viz., of fixing them to the side, very much diminishes this difficulty, as, when once the plan is abandoned of making the shafts a prolongation of the sole, their position is no longer dependent on that of the body of the cart, but may be varied to suit the objects for which it is built, or the size of the horses employed by the owner. By this arrangement for preserving in a great measure the horizontal position of the shafts in carts with low bodies, together with the form of harvest frame pointed out above, these carts are enabled *to carry corn or hay with as great safety as any four-wheeled vehicles;* and this point being once established, it is clear that there is no

longer any necessity for incurring the expense of having waggons or carts expressly for harvest purposes, as the ease and quickness with which single-horse carts can be worked more than make up for the additional load carried by waggons. On the whole, the principles of construction of Mr. Busby's cart are considered more correct than those of any other in the Exhibition, and he has made great advances towards the production of a good cart of all work. His cart has therefore received the distinction of being named in the award of the Council medal; but it should be borne in mind that the medal is awarded to the improved principle of construction, and that it is not intended to stamp this cart as a model in respect of shape, size, and other points of secondary importance, which may be varied to suit the taste or the wants of the purchaser.

2. Crosskill's wheels are deserving of notice, being made by machinery, and accurately fitted. His operations being conducted on a large scale, he is enabled to furnish them at a moderate price.



Crosskill's One-horse Cart.

3. The cart made by the Messrs. Gray, of Uddingston, near Glasgow, has been awarded a medal, though it is considered too high, and that the naves are unnecessarily loaded with iron. The wheels, also, are too much out of the perpendicular, showing that the arms are bent, and their under surfaces not horizontal. As this determines whether the weight of a cart, and consequently of the load, shall rest on a level bed or an inclined plane, it is a point of importance. The deviation in this instance is small; but as it is a fault which a few years back was almost universal, and was in many cases carried to a very mischievous extent, no opportunity should be lost of calling attention to it wherever it is observed. Having thus pointed out what are considered to be the faults of Mr. Gray's cart (the same may be said of the Scotch carts as a class), it is but justice to him to point out that in many respects it is deserving of great praise. The Scotch iron-work is notoriously excellent, and in Mr. Gray's case it is just what it should be, substantial and well finished, and (with the slight exception above-mentioned) with nothing redundant. *It is also due to the Scotch wheelwrights to bear in mind that during the dark ages of English agriculture, when it was scarcely possible to meet with even a tolerably well-made cart in the central or southern parts of Great Britain, and when there seemed to be a rivalry amongst implement makers which could pile up the largest amount of unnecessary wood and iron in the form of a waggon, the Scotch carts universally retained their compact form and workmanlike character; and from being used by improving farmers in various parts of England, tended very much to originate that reform in carts and waggons which is now making such rapid progress.*

Waggons.—It is difficult to conceive why the use of waggons is still retained in particular districts, unless for the purpose of wearing out what has been already paid for, and cannot be disposed of without a great sacrifice. The fact that those who use waggons are also obliged to have carts for leading manure, root crops, &c., ought to decide the question, inasmuch as it necessarily follows that a double amount of capital is required in the first instance, and greater expense sustained ever after in repairs, renewals, and providing house-room for this unnecessary number of wheel-carriages. On a large farm it is certainly convenient to have a waggon for the removal of poles, furniture, or other bulky articles; but these are exceptional cases, and the ordinary routine of farm-work can be at least as well carried on by single horse carts as by waggons. This has been proved on several different occasions by experimental trials, undertaken by the respective advocates of two and four wheeled vehicles for the express purpose of deciding the point. The great necessity at present existing for the introduction of every practicable economy will doubtless eventually substitute light carts for waggons, and in the meanwhile something would be gained by introducing light, cheap, pole-waggons in the place of the cumbrous shaft-waggons which are too frequently met with.

Mr. Crosskill's waggon was considered a very good specimen of an improved waggon, being light, low, and cheap (price 26*l.*, including both pole and shafts). The advantages of a pole over shafts are, that horses can draw a greater weight when yoked abreast than at length; that two horses share the load down hill which is frequently injuriously heavy for one; and that the team can turn in less room, and is altogether more manageable.—H. S. Thompson.

Mr. Busby, it will be observed, by placing his shafts on the side of the cart, has lowered his cart. He has lowered it as much as one in four, thereby diminishing the toil of filling carts with dung, stones, earth, &c., to the amount of one quarter. If we calculate how many thousand arms are employed in this way throughout England for many weeks in the year, we shall find that this improvement, simple as it is, will save no small aggregate amount of misapplied strength to the country at large.

Having gone through the three classes of implements with which the land is first prepared, the crops next cultivated, and the grain afterwards harvested, and having found them to stand well the test of economy by which all machines must be tried, we have now to examine the fourth, by which the corn is lastly made ready for market.

IV. Preparation for Market.

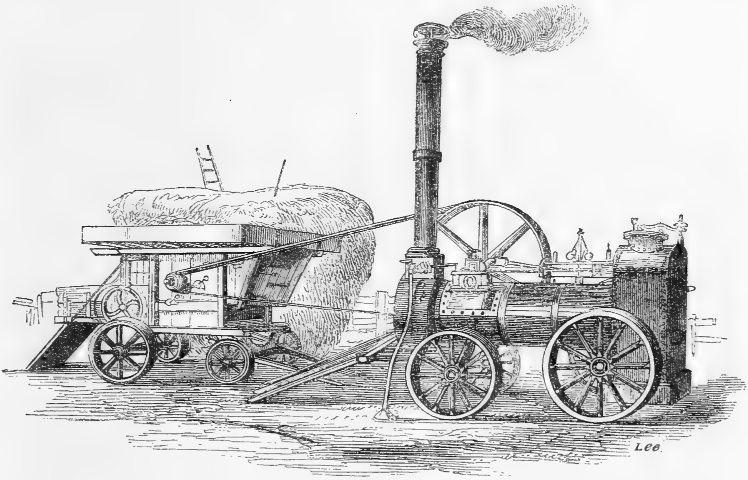
1. *Moveable Steam-engines.*

Every visitor of the Agricultural department must have been struck with the little steam-engines, which, though of pigmy dimensions if compared with the great railway racers, showed the same compactness of form and the same disposition to work. They connected the ruder tools of husbandry with machinery

fitted for more intricate ends, and showed palpably that agriculture had not kept aloof from the spreading dominion of steam. *Fixed* steam-engines have been long used in Northumberland and East Lothian, in which spirited counties every farm has its tall chimney. These *moveable* steam-engines have been called forth by the Royal Agricultural Society within the last ten years, and appear preferable in general to the fixed engines for the following reasons:—

If a farm be a large one, and especially if, as is often the case, it be of an irregular shape, there is great waste of labour for horses and men in bringing home all the corn in the straw to one point, and in again carrying out the dung to a distance of perhaps two or three miles. It is therefore common, and should be general, to have a second outlying yard. This accommodation cannot be reconciled with a fixed engine.

If the farm be of a moderate size, it will hardly—and if small will certainly not—bear the expense of a fixed engine: there would be waste of capital in multiplying fixed engines to be worked but a few days in a year. It is now common, therefore, in some counties for a man to invest a small capital in a moveable engine, and earn his livelihood by letting it out to the farmer.



Hornsby's Steam-engine and Holmes's No. 8 Machine.

But there is a further advantage in these moveable engines, little, I believe, if at all known. Hitherto corn has been threshed under cover in barns; but with these engines and the improved threshing-machines we can thresh the rick in the open air at once as it stands. It will be said, How can you thresh out of doors on a wet day? The answer is simple. Neither can you move your

rick into your barn on a wet day; and so rapid is the work of the new threshing-machines, that it takes no more time to thresh the corn than to move it. Open-air threshing is also far pleasanter and healthier for the labourers, their lungs not being choked with dust, as under cover they are; and there is, of course, a saving of labour to the tenant not inconsiderable; but when these moveable steam-engines have spread generally, there will arise an equally important saving to the landlord in buildings. Instead of three or more barns clustering round the homestead, one or other in constant want of repair, a single building will suffice for dressing corn and for chaff-cutting. The very barn-floors saved will be no insignificant item. Now that buildings are required for new purposes, we must, if we can, retrench those buildings whose objects are obsolete. Open-air threshing may appear visionary: but it is quite common with the new machinery; nor would any one perform the tedious manœuvre of setting horses and men to pull down a rick, place it on carts, and build it up again in the barn, who had once tried the simple plan of pitching the sheaves at once into the threshing-machine. These moveable steam-engines have been gradually improved by the yearly trials of the Agricultural Society. It will be seen by Mr. Carr's Report * that such yearly trials are still needed, as the worst of

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* The mode of ascertaining the amount of duty done, and weight of coal consumed, in a given time by each engine, was the same as that adopted by the Royal Agricultural Society of England at their Annual Show of Implements and Machinery; and the dynamometer used for the trial was the same as the one supplied to that Society by Messrs. Easton and Amos, their consulting engineers.

Messrs. Tuxford and Sons presented the novelty of placing their cylinder and working parts in a wrought-iron box at the end of the boiler, having a pair of doors to lock the whole up when not in work, which I certainly think a good idea, and of some practical importance. But to gain this, the tubes at the smoke-box end were rendered difficult to be got at. There were two engines brought to the trial-yard upon this construction, one a six-horse direct action upright cylinder, the other a 4-horse oscillating; but the former worked out the most duty with the least fuel.

Messrs. Hornsby and Son were distinguished by placing their cylinder inside the upper part of the fire-box, the whole of which, together with the rest of their boiler, was carefully felted and lagged with wood; and they had a well-constructed water-heating apparatus in their smoke-box, which also helped to produce the satisfactory result of great economy in fuel.

Messrs. Garrett and Son in their engine had made a great effort to combine lightness with strength, having substituted wrought for cast iron in the bearing for crank-shaft and other parts. Their boiler presented a great amount of heating surface, but the fire-box, to insure greater strength and a less amount of flat surface exposed to steam pressure, was made partially oval, and considerably smaller than most of its competitors. The fire-bars being above the level of many of the tubes of the boiler, and the flame having to descend over a bridge, the manufacturers expressed themselves quite aware that this construction of fire-box would prevent their standing quite so well as some with respect to fuel consumed, but considered that superior strength, lightness, and portability would more than compensate, this class of engine seldom working more than a few months in the year, and having to be conveyed from farm to farm. And I certainly considered this engine the most portable, for its power, of any exhibited. During the trial some derangement took place in the slide, so that the result was not so favourable; but upon the engine being put through a second trial with Messrs.

those exhibited consumes three times more coal than the best. Mr. Locke, M.P., whose engineering experience gives weight to his judgment, thinks that in other respects too they might be still further improved:—

To P. Pusey, Esq., M.P.

London, 11, Adam-street, Adelphi,
July , 1851.

Dear Sir,

The detailed Report of Mr. Carr, of the results of the experiments made on the portable steam-engines, has already been presented to the Jury over which you preside; and as you desired from me a short statement of my views of Mr. Carr's Report, I beg to send you the following:—

You will find in the tabular statement of the consumption of fuel, that the several makers stand in the following order of excellence:—

Messrs. Hornsby and Son	6·79 lbs.	per horse power.
,, Tuxford and Sons	7·46	,,
,, Clayton, Shuttleworth, and Co.	8·63	,,
,, Barrett, Exall, and Andrews	9·20	,,
,, Garrett and Son	11·65	,,

Clayton, Shuttleworth, and Co.'s, to test the comparative strength of the Llangennech and Newcastle coals, she worked out to a decimal the same number of pounds of coal burnt per horse-power per hour as her competitor, which, allowing for the proved difference in the strength of the coal in favour of the Welsh, would have given Messrs. Garrett 8·63 lbs. of that coal burnt per horse-power per hour instead of 11·65, as shown in the tabular statement; which more favourable result I think them quite entitled to, as the derangement in the slide was purely accidental.

Messrs. Clayton and Co.'s engine was exceedingly simple, and worked well; the governors had perfect control during the trial, which was passed through with great steadiness and credit to the makers.

As regards the other engines, I will proceed to notice them in the order as tested:—

Messrs. Hensman and Son's 4-horse, of moderate workmanship, was evidently the production of a novice. The boiler was too small for the power, and the consumption of fuel more than as much again as most of the first-class engines.

Mr. Butlin's 4½-horse: workmanship moderate; arrangement of working parts simple; and duty done for coal consumed fair when compared with others of its class.

Mr. Caborn's 9-horse: workmanship moderate; arrangement of engine ill designed; and entire weight far too great to be generally suitable for a portable engine. The boiler being a large one, with considerable heating surface, the duty done was comparatively good.

Messrs. Barrett, Exall, and Andrews' 4½-horse: workmanship moderate. The cylinder and crank-shaft bearing in this engine were placed upon the same base-plate, which was bolted to the boiler, an arrangement giving superior strength and steadiness in working. These makers adopted a link motion, controlling the slide-valve and worked in connexion with the governor, which we think a very needless complication, and worked very unsteadily. The boiler was large for the size of the engine, and the duty done for coal consumed was more nearly approaching its first-class competitors; so that, as a whole, I cannot speak less than favourably of the engine.

Mr. Burrell's 6-horse: workmanship fair, and arrangement of working parts simple and good, and consumption of fuel comparatively moderate; so that in this case also I must report favourably.

Messrs. Roe and Hanson, Strand, London, 4-horse: workmanship very inferior; general arrangement ill-designed and clumsy; and cast iron used freely in the place of wrought. The coal consumed for duty done was three times that of the best engines.

Messrs. Ransomes and May brought an engine to the trial-yard, but from some cause

In a subsequent trial, however, made to test the strength of Llangennech coal with Messrs. Shuttleworth's engine, it appears that both engines burnt precisely the same amount of fuel; and Mr. Carr has deduced from this circumstance that, but for some accidental derangement in the slide, in the main tabulated experiments the consumption of Messrs. Garrett's engine, which was 11·65 lbs. per horse-power, would not have been more than Messrs. Shuttleworth's, or 8·63 lbs. per horse-power.

This mode of reasoning is, I think, liable to objection; and I allude to it with a view of preventing an undue importance being attached to it. Besides, I do not entirely concur in the remarks made by Mr. Carr on the construction of these two engines.

Messrs. Garrett's fire-box is, in my opinion, decidedly inferior to Barrett, Exall, and Co.'s; and the workmanship generally is not superior. It is lighter, and so far it is better; but whether the smallness of the fire-box, to avoid weight, may not entail other disadvantages, is a question on which a doubt may fairly arise.

As regards the engine of "Ransome and May," which, from some accidental defect, did not go through a trial, I would beg to say, that in point of workmanship, it is equal, if not superior, to any of the engines

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it could not be made to work. It was a trunk engine, which, in so small a power as 5-horse, would give rise to much extra friction.

At the close of the trials, two engines, viz. Messrs. Garrett's and Messrs. Clayton's, were put through a second trial, to test the difference in steam-generating power between the Llangennech coal used in these trials and the best Newcastle, when the difference in favour of the former was found to be as 8·63 to 11·3 lbs. of coal burnt per horse-power per hour.

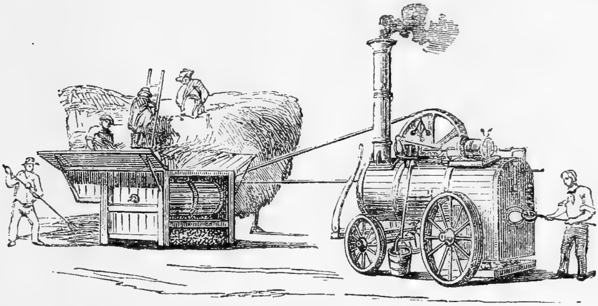
Tabular Statement of Results.

Names of Manufacturers.	Nominal Horse-power.	Time getting up Steam.	Coal used in getting up Steam.	Coal burnt per Horse-power per Hour.
		minutes.	lbs.	lbs.
Tuxford and Sons, No. 1	6	53	56·68	7·46
Ditto ditto No. 2	4	41½	35·60	10·80
Hensman and Son	4	33	29·00	18·75
Hornsby and Son	6	49	35·23	6·79
Butlin	4½	50	42·00	14·71
Garrett and Son *	5	42	26·50	11·65
Caborn	9	44	52·00	12·48
Clayton, Shuttleworth, and Co., No. 1	6	32	35·40	8·63
Clayton, Shuttleworth, and Co., No. 2	6	42	Withdrawn.	
Barrett, Exall, and Andrews	4½	26	25·56	9·20
Burrell	6	28	35·00	13·10
Ransomes and May	5	70	Withdrawn.	
Roe and Hanson	4	83	75·20	25·80
* Garrett and Son's slide was wrong in this trial, but in a second experiment, tried with Newcastle coal, this engine worked out what would equal				8·63

CHARLES JOHN CARR, Belper.

tried. I think the connecting-rod might be lengthened with advantage, but in other respects it is, I think, a good, serviceable engine. As regards the other engines, I agree entirely with the remarks made by Mr. Carr. If I might be permitted to suggest a little advice to the makers of these engines, I would beg of them to attend more to the proportions of the various working parts, and less to external ornament. There is a want of good proportion in several of the engines, and this, to a mechanic or an economical farmer, is of more importance than a profusion of brass.

JOSEPH LOCKE.



Barrett and Exall's Steam-Engine.

Much progress, however, has been made, as our best engine now consumes less than 8 lbs. of coal per hour per horse-power; whereas an engine made by the winning manufacturer of four years ago consumed 28 lbs., that is four times as much fuel for the same work.

2. *Threshing-machine.*

This is the most complicated agricultural machine in general use; but, though it has also been long in use, and though repeated trials have been made of competing threshing-machines at our great agricultural show, it was not till the Norwich meeting in 1849 that a very singular discovery was made of their great imperfection. It occurred to the consulting engineer, Mr. Amos, that the draught of the common threshing-machine, worked by horses, should be tested when empty; and it was ascertained that some of the best 4-horse machines required no less than 3 horses, putting out their strength as when at plough, to keep the machinery in motion without threshing at all. In other words, of the four horses dragging round in their weary circle, three were overcoming the resistance of the machinery; one only was threshing the corn. Technically speaking, the duty performed was 25 per cent. only. So little, too, had the makers studied the principle of construction, that this enormous waste of power was capriciously divided between the barn-works and horse-works.

To quote Mr. Thompson, of Moat Hall, whose Reports always show that he has mastered his subject—"The machines of Messrs. Garrett and Woods furnish an excellent illustration of this point, the whole friction being in these cases 2·78 and 2·81—all but identical; the friction of the barn-works being, however, 2·07 and ·46, while that of the horse-works was ·71 and 2·35." Thus the makers were working so much in the dark, that, if the two best of the correlative parts had been put together, one horse in the four would have overcome the resistance, and a duty of 75 per cent. would have been achieved; but if unfortunately the two worst had been mated, the resistance of the 4-horse machine would have amounted to four horses and a half before any corn was put in for threshing, and there would have been no duty at all.

The same rigid trial was applied to the threshing-machines shown at Exeter in the following year. It then appeared that Messrs. Garrett had profited by the lesson, and reduced their dead resistance from $2\frac{4}{5}$ to $1\frac{1}{5}$, or one-half. Yet there was still found a vast difference in the power required by the competing machines. For threshing 100 sheaves in a minute, the two extremes of power required were as $14\frac{1}{4}$ and 36; and the work of the machine which required triple power was inferior to that of the machine which required least power. This short summary of what has been done already seemed necessary in order to show the interest attaching to the following Report by Mr. Thompson of the trial in the third year for the present occasion:—

1. Threshing-machines may be divided into two classes—those adapted for steam or water power, and those intended to be worked by horses. In the trial of the latter it is clearly desirable that the horse-works should be tested, and on this occasion, in the absence of the ingenious apparatus invented by Mr. C. E. Amos, of the Grove, Southwark, for this purpose, repeated attempts were made to obtain a satisfactory trial by the use of the dynamometer or draught gauge. But after various methods had been fairly tried, it became evident that the results obtained were not sufficiently accurate to warrant their being made public, and the trial of the horse-works was abandoned, and the whole attention of those who conducted the trials devoted to the more important part of the machines, known as the barn-works. The accompanying tabular form shows the results obtained, which were arrived at in the following way.

The steam-engine selected to drive the threshing-machines was itself tested to ascertain the net pressure of steam which represented one-horse power. An apparatus was then attached to it, which registered on a counter the revolutions of the driving-pulley. As each machine was brought up for trial, the maker was asked how many horse-power he required, what number of revolutions per minute he wished the drum to make, and the exact dimensions of the driving-pulley. From these data a calculation was made of the pressure of steam required in each case, and

the supply of steam in the boiler of the driving-engine was so adjusted that the calculated pressure was maintained during the trial.

On reference to the tabular statement it will be observed that col. 1 gives the "nominal horse-power," as stated by the makers; col. 2 gives the horse-power corresponding to the power of steam actually employed during the trial. The figures in these columns are for the most part identical, it being wished that the machines should be tried in accordance with their designation—*i. e.* that a four-horse machine should be worked by steam of four-horse power, &c. Some of the machines, however, could not be worked without additional power, which is recorded against them in col. 2. In col. 3 are given the revolutions made by the driving-engine whilst threshing the allotted quantity of wheatsheaves, viz. 2½ cwt. Col. 4 shows the net pressure of steam at which each machine was worked, and which had been previously calculated from the data above-mentioned. Col. 5 shows the comparative time of performing the same amount of work. This, it should be mentioned, is not the observed time, but the time calculated from the registered revolutions of the engine. The pressure of steam and the number of revolutions per minute which were equivalent to the horse-power applied to each machine having been ascertained, the whole number of revolutions made during the trial, divided by the calculated number per minute, gave the number of minutes required for the performance of the work at the specified power and speed of drum. The figures in col. 6 represent the horse-power that would have been required in each case to do the work in one minute; and show therefore, at a glance, the performances of the several machines in respect of speed and power combined. The lowest figures represent the most satisfactory results. Col. 7 shows the quality of the work done in respect of the three points of "clean threshing," "broken grain," and "state of straw." In each case a number is assumed to represent perfect work, which is considered to bear a proper proportion to the importance of the point—so that the total number obtained by each machine, as shown in the last column, may fairly represent the comparative goodness of the work.

The second trial was conducted in precisely the same manner as the first, the only change being that barley was threshed instead of wheat. Those machines only were allowed to compete which had acquitted themselves satisfactorily at the first trial.

For the guidance of those who are not in the habit of examining tabular statements, it may be useful to point out that the two columns to which attention should be particularly directed are those numbered 6 and 7—the latter being the most important. On ascertaining by the "total" number in col. 7 that a machine has done its work well, col. 6 should next be consulted to ascertain whether under that head it received a high or low figure; if the former, it must be either slow in its performance or heavy in its draught, but, if the latter, it may be inferred that it had threshed *wheat* well, and the second trial would be referred to to ascertain its capabilities with respect to *barley*. An examination of this kind will show that the machines which stand first in order of merit are those of Messrs. Holmes, Hensman, and Garrett, and their performances having been in all respects satisfactory, medals were awarded to each of them.

The shaker attached to Messrs. Holmes's machine was especially commended as being very efficient, and yet adding little to the draught of the machine.

H. S. Thompson.

First Trial.—Wheat.

	1	2	3	4	5	6	7			
	Nominal Horse-power	Horse power required whilst Threshing.	Revolutions of driving-pulley as shown on counter.	Net pressure of Steam in lbs.	Minutes in Threshing $2\frac{1}{4}$ cwt. of Wheatsheaves at the specified power and speed of drum.	Horse-power required to Thresh $2\frac{1}{4}$ cwt. of Wheatsheaves in one minute.	Quality of Work.			
							20 represent perfect work.	12 represent perfect work.	8 represent perfect work.	Total.
							Clean. Threshing.	Broken Grain.	State of Straw.	
					min. sec.					
1. Hornsby . . .	4	4	616	15·76	4 13	16·88	18	9	4	31
2. Blythe	4	4	407	15·50	2 41½	11·76	10	12	7	29
3. Garrett . . .	6	6	260	32·00	2 21	13·96	18	12	8	38
4. Crosskill . . .	4	4	305	19·00	2 27	9·84	16	12	8	36
5. Hensman . .	4	4	358	17·50	2 40	10·67	20	12	8	40
6. Caborn	6	6	417	26·00	3 5	18·48	20	8	4	32
7. Barrett and Co.	6	6	336	26·00	2 58	17·88	16	10	8	34
8. Ransome . . .	4	6	368	26·00	2 44	16·44	18	6	6	30
9. Holmes	6	6	248	28·50	2 0	12·06	20	12	7	39
10. Smith	3	6	595	24·00	4 0	24·00	20	11	7	38

Second Trial.—Barley.

1. Garrett	..	..	160	32·00	1 27	8 72	20	10	8	38
2. Crosskill . . .	..	..	346	19·00	2 47	11 16	20	11	8	39
3. Holmes. . . .	..	..	168	28·50	1 20	8 19	20	12	8	40
4. Hensman . . .	..	..	195	17·50	1 27	6 62	15	12	8	35

The difference, as shown by the table, in the power required by different threshing-machines for threshing a given quantity of straw, which was 1 to 3 at Exeter, is not much less now, being still as high as 1 to 2½. The speed, however, with which the straw is passed through the machine must not, of course, be made the sole test of excellence. Clean threshing is a most material point, in which some machines are very deficient, as is proved after rain by the grassy verdure of a straw-heap so threshed. Thus the easiest working machine, Mr. Crosskill's, seems to have gained that ease at the expense of its efficiency, as appears in the column which registers the cleanness of the threshing. On the other hand, clean threshing may be obtained by beating the sheaves too roughly, as must be the case with Mr. Hornsby's, which bruises the straw, and, what is worse, breaks the grain. Still, the power required by the three prize machines averages only about 12, while the maximum of power required is just double, namely, 24, by Mr. Smith's, which, therefore, of course wastes half the power, whether of horses or steam, that may be applied to it.

A separate trial, it will be seen, was made with barley. Long as the threshing-machine has been known, the maltsters in most counties refuse to buy barley unless threshed by the flail, because

most machines bruise the grain and destroy its power to germinate. The assertion that malting barley could be threshed by machine would, in many parts of England, simply be disbelieved. Yet where the best machines are used, the maltsters no longer object to barley so threshed; so that it is most important to test all threshing-machines with barley. Enough, however, has been now demonstrated to convince farmers that they should no longer buy blindly the threshing-machine which comes nearest to hand, buying thereby double or perhaps treble labour for the same or worse work, and leaving their barley, which is, probably, half their corn-crop, to the tedious work of the flail, though the labourers themselves begin to regard that work as too irksome.

There remains only in this class of machinery to apply the test of economy, and compare the cost of threshing by flail, by horse, and by steam. In the two former cases the rick must first be removed into the barn by eight men, a boy, and two horses—I take the numbers as they have been employed on my own farm, because it is difficult to ascertain such figures, and the comparison will at least be a fair one:—

	s.	*d.*
8 men, at 1*s.* 4*d.*	10	8
1 boy	0	10
2 horses	6	0
Cost of barning . .	17	6

The price of threshing wheat by flail varies, with the yield and the district, from 2*s.* 6*d.* to 4*s.* a quarter. Three shillings then will not be an unfair average. If the rick hold forty quarters, we must add 5*d.* for barning, and the cost will be 3*s.* 5*d.* per quarter.

In threshing with the unimproved machines, I find on inquiry that neither my neighbours nor myself have hitherto got out more on an average than 13 quarters a-day. The supposed rick would take, therefore, three days to thresh:—

	£.	*s.*	*d.*
5 men, at 1*s.* 4*d.*	0	6	8
4 women, at 8*d.*	0	2	8
1 boy	0	0	6
4 horses, at 3*s.*	0	12	0
	1	2	0
			3
3 days' threshing	3	6	0
Barning	0	17	6
	£4	3	6

The old system of horse-machines has cost us, therefore, 2*s.* a quarter. But improvement has been carried further: for

steam-threshing we require additional hands, 16 instead of 10, but we get over three times the work, passing the rick in one day, not three, through the machine. The figures on steam-threshing will be then as follows:—

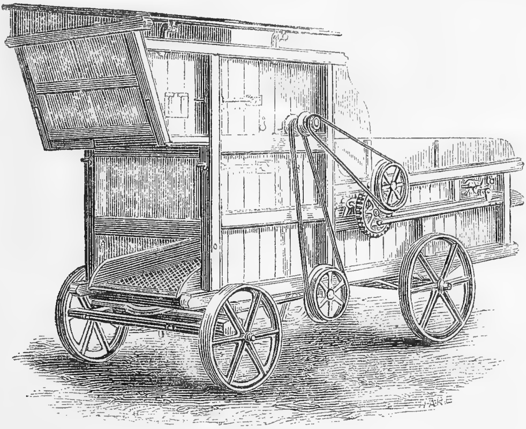
	£.	s.	d.
1 engineer (head carter) . . .	0	2	6
10 men, at 1*s.* 4*d.*	0	13	4
5 women, at 8*d.*	0	3	4
Coals, $3\frac{1}{2}$ cwts.	0	3	6
	£1	2	8

If we make up this sum to 30*s.* for the use of the engine, the cost of steam-threshing will be 9*d.*; the saving, as compared with hand-threshing, 2*s.* 8*d.*, or with horse-threshing 1*s.* 3*d.*—an average of 2*s.* per quarter of wheat—a large saving certainly to be effected in one only of five main departments, but not larger, I believe, than may be shown to arise from the use of improved machinery in most, if not all, of the four other departments as well. It may be objected that credit is given for the value of the horses' labour; and though in valuations horse-work is often charged high, we are apt, I know, as farmers, to regard each particular use of horses as costing us nothing. This view may be even correct on small matters occurring at leisure seasons, but it would be false if applied to a demand like the present, large in itself, distressing also for the horses, and liable to occur at all times of the year. It can have no truth in it at all, when we endeavour, and by reformed implements in all other departments are enabled, to reduce the permanent staff of horses kept on the farm: for this plain reason, that, if we do not carry the reduction throughout, we either press the horses unduly at one time, or require horses to be kept which are useless at other seasons.

Since the trial for the Commission a fresh trial has been made at Beverley. There the prize was awarded to a machine by Messrs. Clayton and Shuttleworth, which not only threshes out 50 quarters in a day's work, but dresses the corn also to a great extent at the same time, yet requires, as the makers state, only 14 hands for both purposes—not more hands therefore than we have employed to get out with horse-machines, and afterwards dress, 13 quarters only:—

	£.	s.	d.
Engineer	0	2	6
Feeder	0	2	6
6 men at 1*s.* 4*d.*	0	8	0
6 women or boys . .	0	4	0
Coals 5 cwts.	0	5	0
	£1	2	0

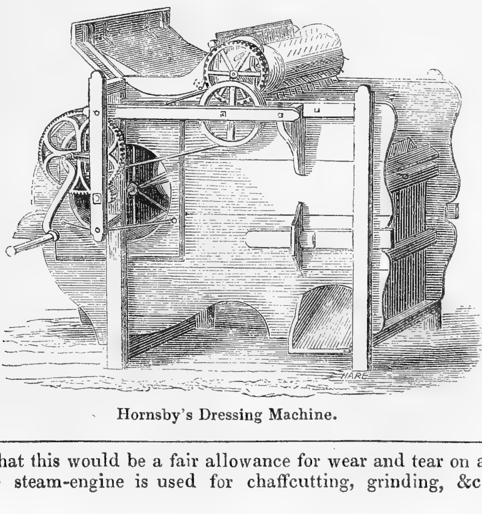
If we add 7*s.* for wear and tear,* we find the wheat to be threshed *and winnowed* for the almost incredibly low sum of 7*d.* only per quarter. Messrs. Clayton and Shuttleworth have therefore now taken the lead in the improvement of threshing-machines.



Clayton and Shuttleworth's Threshing and Dressing Machine.

3. *Winnowing-machine.*

Even winnowing is become a refined process; for instead of trusting the corn to the wind, it is now placed in a machine so discriminating that the best of these, Messrs. Hornsby's,



Hornsby's Dressing Machine.

* I am told that this would be a fair allowance for wear and tear on a farm of 500 acres where the steam-engine is used for chaffcutting, grinding, &c., as well as threshing.

required, on the part of the Judges at the York meeting, specific terms for describing its work more than are easy to understand; but the Judges' account is for that very reason worth quoting:—"Several machines," they say, "were tried, but could not get through the grain, shorts, straws, and chaff, as it came from the threshing-machines, without being choked or requiring much more time than Hornsby's, which did its work well, parting the whole into best corn, good tail, tail, whites, screenings, and chaff, at the rate of above 15 quarters an hour, and dressing over the second time at the rate of above 20 quarters per hour, parting the whole into six parts, as before, in a workmanlike manner." Such masterly mastication and digestion, making the contents of our supposed wheat-rick, 40 quarters, in five hours ready for market, must be appreciated by farmers; and Mr. Hornsby's winnower has not lost character at Kensington, as appears by the Judges' Report:—

Winnowing machines.—Messrs. Hornsby and Son are, above all others, the most successful in these machines, dressing more than double as much corn as any other in *a rough state.* Theirs is fitted with a spike roller, working through a grating, and forms a sort of hopper, separating the corn from the chaff in the rough pulsy state, *as it comes from the threshing-machine*, without being previously riddled; and can be adjusted to suit corn either in rough chaff or in any other state; the second time over, a slide-board is adjusted in front of the grating, and is excellent for finishing the corn for market. We therefore awarded it a medal. Price 13*l*. 10*s*.

Mr. Gooch exhibited a machine which did its work well, but too slow.

C. B. Challoner.

The corn being now fit for the miller, the task of a reporter on agricultural implements fifty years since would have ended; nor is it within this branch to enter on the new process of grinding, by which the finest flour is produced from ordinary red wheat; but though the preparation of food for man belong to another department, there is an entirely new class of implements belonging to this jury which must not be passed over.

V. Machines for Preparing the Food of Stock.

Formerly our farm stock was fed with hay, or turned out to pick over straw, sometimes with whole turnips thrown to them. But practice, anticipating Baron Liebig's brilliant discoveries in animal physiology, found that the labour of the jaws wasted the beast's muscle and thus retarded his progress. Our stock, therefore, are saved even from that exertion, and distinct machines have been invented for mincing each description of food with which the animals are made ready for market. The most common of these is

1. *The Turnip-cutter.*

The test of labour saved cannot, of course, be applied where the labour is applied to a new object. These machines, however, have recommended themselves so widely, that to prove their advantages is almost idle. Still it deserves mention that, in the opinion of good farmers, lambs fed with the aid of a turnip-cutter would be worth more at the end of a winter by 8*s.* a-head than lambs fed on whole turnips, the cost of using the machine being but 1*s.* per head, and of the machine itself 5*l.* only. If this be true—and it has not been disputed—this simple instrument gives a saving of 70*s.* an acre upon the turnip crop. Hitherto the Banbury turnip-cutter has stood almost alone, thousands, I believe, being sold in a year ; but in the Exhibition building it has at last found a rival.

Turnip-cutters.—Three of these implements were tried : that of Messrs. Burgess and Key is upon a different principle to those generally in use ; their implement cuts a very large amount of roots for sheep and beasts at the same time, exceedingly well, and requires a very small amount of power. There is a great facility of changing any of the knives that may become blunt or broken ; and there is a very simple and ingenious method of letting stones or gravel escape before coming in contact with the knives. Price 5*l.* Both for novelty and usefulness we awarded it a medal.

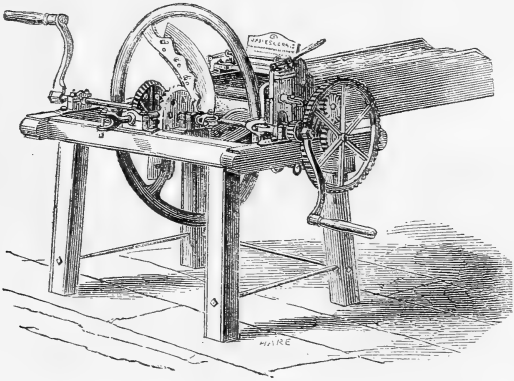
Messrs. Samuelson (successors to the late James Gardener, of Banbury) have very much improved that well-known implement. The framework is made of cast-iron, light, portable, and durable, and well adapted for field work. They have also made a great improvement in the facility of getting at, repairing, or adjusting the knives. Price 5*l.* We awarded a medal.

Mr. Phillipps's turnip-cutter was tried, but could not compete either in construction or work with the other two.

C. B. Challoner.

2. *Chaff-cutters.*

These instruments, which cut straw into very short lengths for feeding stock, are so called because, there not being enough



Cornes' Chaffcutter.

natural chaff for the purpose, artificial chaff was made in this way. At first the straw was cut in a rude box, with a chopper raised by the hand, and cost 2*d.* per basket; then with a circular movement, costing 1½*d.*; and may now be cut by steam-power at not much more than ¼*d.* per basket. The process makes, too, an arable farmer independent of natural meadow; for sheep, it is well known, especially breeding ewes, require much dry food; but this artificial chaff mixed with rape-cake takes the place for them of hay, or hay may be cut with the straw. It is also worth while to cut hay, though consumed by itself. Even in the new circular chaff-cutters we find a difference as to the labour required by them for preparing a given amount of chaff. The difference, indeed, was so great in the trials at York, that it is worth while to quote some of the figures:—

	Price. £.	s.	d.	Weight of Chaff Cut. lbs.	Power required. lbs.	
Cornes .	14	0	0	112	14,126	Did its work well.
Garrett .	10	10	0	112	31,291	
Crosskill.	18	0	0	112	44,800	This machine made very rough work.

This table is most instructive; for we find here three first-rate makers staking their reputation in a public trial on their respective instruments, one of which nevertheless requires three men to do badly what another enables one man to do well. Surely farmers must learn from such results a more careful choice of their implements. It is due to the two makers last named to mention that the lesson was not thrown away on them.

Chaff-Cutters.—Mr. Cornes, of Burbridge, has in the trials at Kensington maintained his previous reputation for the greatest economy of power in proportion to the work performed; also the machines of Messrs. Garrett and Son, and Messrs. Smith and Co., of Stamford (17*l.*), are worthy of the highest commendation, the latter for an ingenious application of a spring lever to throw the rollers out of gear when starting the machine. To these three we have therefore awarded a medal.

C. B. CHALLONER.

3. *Linseed and Corn Crushers.*

The same extraordinary disparity of power required was found also two years since, at the Norwich meeting, in this class of implements:—

	Linseed Crushed. lbs.	Power required. lbs.
Stanley . .	112	24,238
W. Nicholson .	112	94,080

In fact this is the greatest difference we have found yet in any machine worked by hand, being about four to one: so that to

obtain the same work four men must turn one machine, while a single labourer turns the other.

Linseed and Corn Crushers.—Mr. Stanley, of Peterborough, at present stands unrivalled with this machine. By his recent improvement of a lever in front to relieve the pressure when the corn is first let in upon the rollers, he has perfected this machine, which was much needed, as machines on this principle have been made by various other makers, but have always been subjected to the inconvenience of being choked with the corn at starting. On these trials, Messrs. Stanley's machine required less power to drive it than others; and was, in consequence, awarded a medal.

Messrs. Barrett and Exall's crusher merits commendation. Messrs. Garrett and Son have introduced some additional motions, and have thereby added considerably to the friction of their machines.

C. B. Challoner.

4. *Oil-Cake Bruisers.*

Not being able to procure the thick cake, the machines were tried with the small 3-lb. cakes.

Mr. Nicholson, of Newark-on-Trent, exhibited a machine, the price of which was 5*l.*, which did its work very well. Messrs. Hornsby brought two very excellent machines (I think the larger one is to be preferred), breaking for beasts, sheep, and manure equally well. To each of these exhibitors a medal has been awarded. Others, on the same principle, were tried, but did not do their work so well.

C. B. Challoner.

5. *Mills for grinding fine Meal.*

Mills for grinding fine Meal.—The best metal mills that have been produced for the operation are those of Messrs. Hurwood, of Ipswich, and Messrs. Crosskill, of Beverley: that of Messrs. Hurwood, which is composed of a series of cutting rings screwed upon a cast-iron plate, having the dress somewhat resembling the common millstone; the drift increased from the centre, to enable it to clear itself. The rings appear to be easily replaced by new ones when worn out, which is a great advantage over the old mills. This mill did 6 bushels of barley per hour, with a power of a little more than three horses, and is applicable to beans, barley, and oats. We awarded it a medal.

Messrs. Crosskill's is an American invention, consisting of a number of cast-iron plates turned up in circular grooves, either fine or coarse, dependent upon the work required, and fixed *eccentric*, which gives them a sort of clip. The mill requires great power, and should be driven at great speed. By changing the plates it will grind anything from linseed to flintstones. In the trials at Kensington it ground linseed, barley, beans, and oats very well. Price 28*l.* We awarded it a medal.

Mr. Bentall, of Woodbridge, exhibited a small steel mill, requiring very little power, which split beans very well, at the rate of ten pecks per hour, and deserves commendation. Price 6*l.* 6*s.*

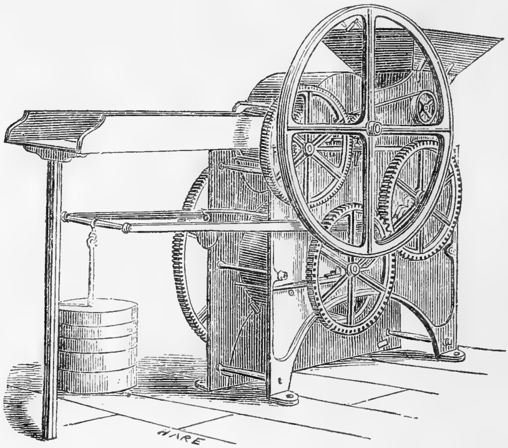
C. B. Challoner.

6. *Gorse Bruisers.*

These implements have reached a high degree of perfection, but whether their application has increased in proportion, or

has been found profitable, there is no sufficient information at hand.

Mr. Burrell's, of Thetford, did the most and the best work; and although it consumed rather more power than some others in bruising the gorse, it did oats and linseed at a moderate amount of power. We therefore awarded it a medal. Price 27*l.*



Burrell's Gorse Bruiser.

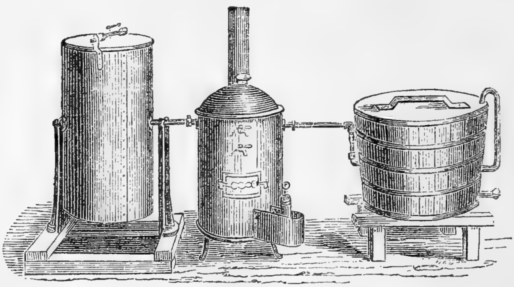
Messrs. Barrett and Exall, of Reading, exhibited a machine worthy of commendation. Price 25*l.*

Messrs. White, of Holborn, exhibited a machine that reduced the gorse into the most pulpy state, but required a great increase of power. The price (60*l.*) is beyond the reach of a farmer, which, I am told, they propose to reduce; but that was the price officially announced at the time of the trials.

C. B. Challoner.

6. *Steaming Apparatus.*

Besides these various modes of subdividing, it has been often proposed to cook the food of animals; but the practice has not



Stanley's Steaming Apparatus.

spread widely, and the advantage must be regarded as doubtful, excepting as regards the steaming of potatoes for pigs; but even diseased potatoes, if not too far gone, by being thus treated may be rendered good victuals and be stored up for months. It seems hardly worth while to set up expensive fixtures for this purpose only, especially as we have an excellent apparatus, Mr. Stanley's, which, like Soyer's magic stove, may be used when and where it is wanted. When tried* at York it heated 126 gallons of water while another heated but 70, little more than half, with the same allowance of fuel; yet this inferior one had been the best two years before.

VI. Churns.

The pace of the churn was first accelerated by the Americans, who sent us over a churn within the last few years that produced butter after ten minutes' work. It is not quite clear, however, whether this speed be compatible with the finest quality, for the New York Agricultural Society was not satisfied with the butter so rapidly made. The time in the present trials was reduced to two minutes, and even to one minute, but in the latter case with cream which, having come from Jersey, had been already half churned by the steam-packet.

Thirteen churns were tried in the first trial, with ordinary cream of good quality; the annexed tabular form will give the results. As will be seen, many of the churns worked equally well, and some of them which did not do so well would perhaps have shown a different result in an atmosphere more congenial to the making of butter. However, in both trials, the small family churn of Lavoisie did its work so well that we awarded it a Medal. Those of Wilkinson, and Burgess and Key, also proved themselves to be excellent churns; and there was awarded to each a Medal. The Belgian churn of Duchêne, though not quite perfect in every part, we consider entitled, as among the foreign churns, to a Medal.

First Trial of Churns.

Exhibitors.	Cream	Time.		Butter.		Residue.	Quality.	Form of Churn.	Thermometer	
	quarts	min.	sec.	lbs.	ozs.				Air.	Cream
Wilkinson	4	11	0	3	8	..	Best.	Wood.		
Tytherchief	10	18	0	9	2	..	Soft.	Tin.	70	69
Destrey	4	16	0	3	12	..	Soft.			
Destrey	9	11	0	8	12	..	Soft.			
Patrick	10	20	0	9	4	..	Soft.			
Burgess and Key	4	10	0	3	12	..	2nd best.	Barrel.		
Drummond, American	6	9	0	5	2	..	Not made.	Wood.	72	71
Lavoisie	2	2	0	1	13	..	3rd best.	Tin.		
Dalphin	6	8	0	5	0	..	Soft.			
Allen	6	7	30	4	2	..	Soft.	..	77	74
De Pourquet	3	9	0	2	6	..	Soft.			
Duchêne	19	9	0	7	9	..	Not all made			
Smith	5	22	0	4	10	..	Indifferent.	Centrifugal.		

* The trial of Mr. Stanley's apparatus was overlooked accidentally, because a trial was thought unnecessary, there being no moveable apparatus in competition; but the jury having decided that no prize should be awarded without trial, the over-

Second Trial, with Jersey Cream.

Exhibitors.	Cream	Time.		Butter.		Residue.	Quality.	Form of Churn.	Thermometer	
	quarts	min.	sec.	lbs.	oz.				Air.	Cream
Wilkinson	4	1	45	4	0½	. .	Best.	Wood, box.	79	75
Burgess and Key . .	4	1	45	4	2	. .	Very good.	Wood, box.		
Lavoisie, French . .	2	0	45	2	2	. .	3rd best.	Tin.		
Clare, French . . .	1	1	45	1	0½	. .	Good.	Tin.		
Duchêne, Belgian .	30	2	30	27	0	. .	2nd best.	Barrel, wood		

C. B. Challoner.

VII. Draining.

This last class of machines, those connected with draining, ought perhaps to have formed the first class, inasmuch as draining is the only road to good culture on land which lies wet; but as much land does not require draining, and as it does not belong to the regular task of the farmer, but is a work to be done once for all by the landlord, the machines employed in this mode of improvement have been reserved to the end.

1. *Tile Machines.*

Twelve years ago draining-tiles were made by hand, cumbrous arches with flat soles, costing respectively 50*s.* and 25*s.* per 1000. Pipes have been substituted for these, made by machinery, which squeezes out clay from a box through circular holes, exactly as macaroni is made at Naples, and the cost of these pipes averages from 20*s.* down to 12*s.* per 1000. The old price was almost prohibitory of permanent drainage, excepting where stones were at hand: the new invention has reduced this permanent improvement to a rate of 4*l.* or 3*l.* per acre, not exceeding in cost the manure given to a single turnip crop in some high-farmed districts. This result has been obtained by a most spirited competition among mechanists, as no less than 34 different tile-machines competed in 1848 at the York meeting. Since then the struggle has been practically between three only, on which, in the present year, we have the following report:—

Trial of Tile Machinery.—I recommend to the consideration of the jury the Tile and Brick Machines of Mr. Clayton, Mr. Scragg, and Mr. Whitehead.

I first tested their capacity in screening the earth. The result of this trial was that in five minutes

Mr. Clayton screened . .	327 lbs.	2 men and boy
Mr. Whitehead . .	361 ,,	2 men
Mr. Scragg . . .	202 ,,	2 ,,

I give the preference to Mr. Clayton's screen, as it clears itself, and the portion rejected consisted almost entirely of small stones, &c.; whereas

sight could not be remedied. There was also a fixed apparatus which could not have been tried.

the screens of Mr. Whitehead and Mr. Scragg retained a large portion of clay.

In the manufacture of large pipes 9 inches in diameter, by horizontal delivery and the use of a cylindrical horse, the machine of Mr. Whitehead was perfect.

Mr. Scragg has much simplified the internal arrangement of his machine by substituting a chain for the rack and pinion: the pipes from this machine were not to be surpassed for regularity and uniformity of shape. After a careful examination of the working of these machines, we recommend the *horizontal* delivery of Mr. Scragg and Mr. Whitehead in preference to the *vertical* delivery of Mr. Clayton, but especially call your attention to Roberts's Patent Hollow and Bonding Bricks as made by Clayton's machine.

A. Hamond.

The pipes so made are placed under ground with narrow spades; but in the form of the narrowest spade, if I may venture to speak from my own experience, it is clear that, so far as regards clay subsoils, a step has been taken backward in substituting a concave tool for the old triangular lance-headed tool of Essex, with which far more work can be done, by less exertion, too, on the part of the labourer. There is hope, however, that on clay soils manual toil will be superseded by the use of

2. *The Draining Plough.*

But for the American Reapers, Mr. Fowler's draining plough* would have formed the most remarkable feature in the agricultural department of the Exhibition. Wonderful as it is to see the standing wheat shorn levelly low by a pair of horses walking along its edge, it is hardly, if at all, less wonderful, nor did it excite less interest or surprise among the crowd of spectators when the trial was made at this place, to see two horses at work by the side of a field, on a capstan which, by an invisible wire-rope, draws towards itself a low framework, leaving but the trace of a narrow slit on the surface. If you pass, however, to the other side of the field, which the framework has quitted, you perceive that it has been dragging after it a string of pipes, which, still following the plough's snout, that burrows all the while four feet below ground, twists itself like a gigantic red worm into the earth, so that in a few minutes, when the framework has reached the capstan, the string is withdrawn from the necklace, and you are assured that a drain has thus been invisibly formed under your feet. The jury decided as follows:—

The implement went through the trial very well, laying in the tiles with great apparent ease, worked by *two* horses, with a capstan which was firmly and easily fixed into the ground, and afforded a firm traction to the plough by means of a wire rope and pulley. Progress has been made, since the implement was exhibited at Exeter, in rendering the level of the drains in a degree independent of the level of the surface; but there

* The machine is made by Messrs. Fowler and Fry, Templegate, Bristol.

Fowler's Draining Plough.

is still room for further improvement in giving to the drain a *uniform* incline.

The award, therefore, of the jury was honourable mention. Since that trial I have thought it right to make further inquiry into the work of the draining plough. In the first place, the trial drains were opened and laid bare from end to end. Straightness is of course one requisite, and the pipes were laid straight; closeness of contact another, and they were perfectly joined. In level, the point on which the jury doubted the perfection of the work, there was some deficiency, which, on entirely flat ground such as this, was a decided fault. That fault, however, has since been remedied for clay land at least. As the plough was shown last year at Exeter, it could not possibly lay a level drain, because, its under and upper parts being fixed at an unvarying distance, any unevenness of an undulatory surface must be faithfully copied by an undulating drain below. This year the two parts were so connected that the workman, by turning a screw, can raise or lower the underground snout which burrows out the drain. But at the trial the use of this screw depended on the workman's judgment, which cannot give the drain absolute accuracy. A balanced level, however, has now been added to the plough, by which the changes of surface are made plain to his eye. Other improvements have also been made in the implement. The horse-power required has been reduced by a fourth, and the windlass at which the horses work need now

be shifted only once in the day. As to the economy of using the draining plough, it is too expensive to purchase, unless for a large landowner, but it may be hired by the year or the month. Its inventor is also ready to execute work at his own risk by contract, at a saving of from one-third to two-thirds on hand-labour, the greater the depth the greater being the saving. I have only seen the actual cost of two drainages that have been made by this plough. They were both without tiles and shallow, being only $2\frac{1}{2}$ feet deep. Taking the highest of them, and adding the cost of tiles, the price of tile-draining land at that depth, and at 33 feet apart, would be 14*s.* only for work, and with $1\frac{3}{4}$-inch pipes, at 15*s.* per 1000, 18*s.* 9*d.* for tiles—all together 1*l.* 3*s.* 9*d.*, including horses and hire of machine. The plough goes as well, however, at a depth of 4 feet, nor could the additional cost be material. The plough has worked on the following farms:—

	Acres.	Depth. ft.	in.	
Mr. Fowler, Melksham . . .	14	2	6	with pipes.
Mr. Newman, do.	10	2	0	do.
Mr. Blandford, near do. . . .	30	3	6	do.
Mr. Purch, Down Ampney . . .	100			without pipes.
Mr. Hall, Brentwood	200	2	6	with and without.
,, Wormwood Scrubbs . .	40	from 2 ft. to 4 ft., with tiles.		
Mr. Harris, Darlington . . .	now working	3	6	

In clay subsoils, with a gentle fall, the success of this new implement seems to be beyond doubt, and in all circumstances the inventor is ready to undertake the risk of the execution.

In now closing this Report, I shall be permitted to say that, although it is impossible adequately to value any productive machinery without detailing its objects and estimating its power to diminish human toil, or to increase the results of that toil, I could not have ventured to enter so far into the practice of husbandry, but for the interest your Royal Highness has long taken in these pursuits, and, above all, from the high concern entertained by you in the welfare of that important class among her Majesty's subjects to whom agriculture affords the means not of harmless or useful amusement merely, but of anxious subsistence, not unaccompanied now with serious misgiving. A sure conviction, founded on no short experience, that those new implements which in the great Exhibition afforded not the least conspicuous testimony to the advance of English skill in devising mechanical means for the abridgment of labour, can practically afford to the English farmer, if rightly understood, important, easy, and immediate assistance, has emboldened me to pursue the necessary chain of evidence with, I fear, tedious minuteness; but that minuteness will, I trust, be excused, if it shall have established any definite truths, which, as affecting the

prosperity of so important a body of men, may be thought in some degree to claim even national importance, and the claim alone will, I well know, have secured your Royal Highness's indulgent attention.

It seems proved, then, that within the last twelve years, since annual country shows of implements were established by Lord Spencer, Mr. Handley, and others yet living, old implements have been improved, and new ones devised, whose performances stand the necessary inquiry as to the amount of saving they can effect. To ascertain that amount precisely is difficult; but, looking through the successive stages of management, and seeing that the owner of a stock-farm is enabled in the preparation of his land, by using lighter ploughs, to cast off one horse in three, and by adopting other simple tools to dispense altogether with a great part of his ploughing—that in the culture of crops by the various drills horse-labour can be partly reduced, the seed otherwise wanted partly saved, or the use of manures greatly economised, while the horse-hoe replaces the hoe at one-half the expense—that at harvest the American Reapers can effect thirty men's work, while the Scotch cart replaces the old English waggon with exactly half the number of horses—that in preparing corn for man's food the steam threshing-machine saves two-thirds of our former expense—and in preparing food for stock, the turnip-cutter, at an outlay of 1*s.*, adds 8*s.* a-head in one winter to the value of sheep—lastly, that, in the indispensable but costly operation of draining, the materials have been reduced from 80*s.* to 15*s.*—to one-fifth, namely, of their former cost; it seems to be proved that the efforts of agricultural mechanists have been so far successful, *as in all these main branches of farming labour, taken together, to effect a saving, on outgoings, of little less than one-half.**

This saving of labour or expense, though large for land—a material certainly very intractable—is small as compared with the saving effected in the weaving of calico or the knitting of stockings. But it is important to observe, on the other hand, that the cost of the means which produce the saving is comparatively insignificant. When the distaff and knitting-needle were abolished, huge factories had to be built, and filled with intricate clockwork of spinning-jennies and looms, costing thousands of pounds. In agriculture we buy a few simple durable tools; and it is evident that a farmer setting up now in business, who, instead of the old waggons with three horses each, should buy one-horse

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* As mere reasoning seldom carries conviction, I may be permitted to mention that whereas in estimates by excellent farmers 12 horses are still assumed to be necessary for a farm of 400 acres, though with improved farming, I find now that I can work 460 acres of a mixed farm with 8 horses, which are by no means confined to the work of the farm.—Ph. P.

carts, and the smaller number of horses required by such carts and by other improved machinery, would find that, without any increase of outlay whatever beyond the old scale, he could acquire all requisite modern machinery, with one exception, indeed—the steam-engine, but the steam-engine is often hired. It is therefore also demonstrated that *the new agricultural machines have, with reference to the amount of saving produced by them, the merit of very great cheapness.*

There is a further effect of machinery upon agriculture which has hitherto been overlooked. The main difficulty of farming has always lain in its uncertainty. Though machinery has not altogether cured, it certainly has much mitigated, this evil. On undrained clays a wet winter may destroy half the yield of the wheat. On the same land drained, the wheat may escape altogether unhurt, and you may also plough heavy land in wet weather when drained, though you could not before. Upon any land wheat may suffer in winter, but in spring the presser settles it in its bed, and the manure distributor with a cheap sprinkling restores it to vigour. In sowing barley earliness may save the crop; but the ground is often too cloddy, though the season is wearing away, and May-drought approaching. This cloddiness may be prevented, as has been said, by the paring plough, or, if it could not be prevented, may be remedied by the clod-crusher, or Norwegian harrow; and besides these implements, the cultivator does the plough's work in one-fourth of the former time, thus enabling the farmer to profit by the auspicious hour of seed-time. And so too with the turnip: the land, being prepared for it in the previous autumn and winter, is moist to receive the seed; the dry drill, supplying it with superphosphate, saves it almost certainly from the fly; or yet more, the water-drill, anticipating the clouds, makes its seed-time independent of weather, while the horse-hoe afterwards preserves it from neglect in the busiest harvest-time. Again, while machinery remedies the absence, it also guards against the inconvenient arrival of rain, by making our hay and now even reaping our corn while the sun shines. It may be further said then, that *machinery has given to farming what it most wanted, not absolute, indeed, but comparative certainty.*

I wish I could add that the use of machinery has advanced as rapidly as its improvement. Still it has advanced greatly, as is shown by the increase not only of implements but of eminent implement-makers, and the sale has never been so great as it has been this year. Yet even the best new machines are not yet adopted into general use. This incomplete progress may, however, easily be accounted for. The farmer, whose life is secluded, has little opportunity of seeing them, and it is remarkable that nearly all our first implement-makers live on the east

side of England, in those four counties from which the other great improvements of agriculture have also proceeded. For threshing-machines again, though universal, until very lately no record of their work has been published, so that a farmer in one county, threshing 13 quarters only a day, could not possibly ascertain that in another county three times that amount was the proper work of a day.

But it must be further admitted, that few even of our best farmers, though they may possess the new implements, carry their use thoroughly out. It seems evident that *the new implements require a new system.* As yet many farmers use the drill and do not use the horsehoe afterwards, the use of which is pointed out by the drill, while most farmers still use the plough previously, which the drill may have rendered superfluous. It is of course very difficult to give up old practices, but the result of the whole inquiry into agricultural machinery appears to be this,—that, inasmuch as the new machinery effects a great saving of labour, and is also exceedingly inexpensive, giving also moderate certainty to a business proverbial for its precariousness, farmers ought no longer to bind themselves down by ancient customs in husbandry, but should consider at once how these practices may be reformed altogether, in order thoroughly to carry out the advantages of modern mechanics. They should look as much to a shed furnished with suitable implements as to their stables, remembering that the best of these implements, though it cost as much as a horse, may take the place of a horse, and, furthermore, when once purchased does not, like the horse, entail a weekly expense afterwards. That this extension as well as improvement will come to pass in the mechanics of husbandry there is no reason to doubt, nor that both have been accelerated by the opportunity for careful study of agricultural implements which has been afforded during five months through their exhibition, under your Royal Highness's auspices, among all the other products of human industry.

Appendix to Implement Report.

Account of a subsequent Trial of the American Reapers.

By H. S. Thompson.

Reaping-machines.—After the trials at Pusey, the proprietors of M'Cormick's reaping-machine challenged all other implement makers to produce one of equal merit, and great interest was excited in the North Riding of Yorkshire when it was known that Messrs. Deane, Dray, and Co., the purchasers of Hussey's reaping-machine, had accepted the challenge, and that the trial was to come off near Guisborough, at the annual meeting of the Cleveland Agricultural Society. Under the auspices of this Society a jury of twelve practical farmers was appointed to give the two

machines a full and fair trial, and to deliver their verdict on the following points, which had been previously drawn up in writing, and approved by the competing parties as being proper tests of the value of such implements. The jury were called upon to decide which machine—

1. Cut the corn in the best manner.
2. Caused the least waste.
3. Did the most work in a given time.
4. Left the corn in the best order for gathering and binding.
5. Was best adapted for ridge and furrow.
6. Was the least liable to get out of repair.
7. At first cost was less price.
8. Required the least amount of horse labour.
9. Required the least amount of manual labour.

The machine which was found by a majority of the jury to excel in the greater number of the above points was to be pronounced the best implement.

The trial was fixed for Thursday, the 25th of September; and as foreman of the jury I was present on that day. The weather was, however, very unfavourable; a severe storm of rain and wind set in just as the trial commenced, and, though both machines were worked for a short time, no decisive opinion could be formed of their respective merits. The trial was therefore postponed till the following Saturday, and, being unable to attend on that day, the Rev. W. Wharton, of Barningham, kindly consented to take my place. The two machines were again tried on Saturday, September 27, on wheat and barley. Both made good work when the corn was standing or laid towards the machine, but when cutting across the lay of the straw, Hussey's had a decided advantage. The report of the jury is as follows:—

"The jury regret exceedingly the most unfavourable state of the weather on the days of trial (a perfect hurricane raging the whole of the first day), and their consequent inability to make so full and satisfactory a trial as they could have wished. The machines were tested on a crop of wheat, computed at 25 bushels per acre, very much laid; and on barley at 25 bushels per acre, very short in the straw, and if possible more laid than the wheat. The jury, taking the different points submitted to their consideration, express—

"1. Their unanimous opinion that Mr. Hussey's machine, as exhibited by Messrs. William Dray and Co., cut the corn in the best manner, especially across ridge and furrow, and when the machine was working in the direction the corn laid.

"2. By a majority of eleven to one, that Mr. Hussey's machine caused the least waste.

"3. Taking the breadth of the two machines into consideration, that Mr. Hussey's did most work.

"4. That Mr. Hussey's machine leaves the cut corn in the best order for gathering and binding. This question was submitted to the labourers employed on the occasion, and decided by them, as above, by a majority of 6 to 4.

"5. Their unanimous opinion that Mr. Hussey's machine is best adapted for ridge and furrow.

"6. This question was referred by the jury to Mr. Robinson, foreman to Messrs. Bellerby, of York, a practical mechanic of acknowledged ability, whose report is appended below.

"7. That Mr. Hussey's machine at first cost is less price.

"8, 9. The jury decline to express a decided opinion on these points in consequence of the state of the weather.

"The trials took place on the farm of Robert Fawcitt, of Ormesby, near

Middlesbro'-on-Tees, who in the most liberal and disinterested spirit allowed his crops to be trodden down and damaged to a very great extent, especially on the 25th, when in spite of the storm an immense crowd assembled to witness the trials. The jury cannot conclude their report without expressing the great pleasure they have derived from seeing two machines brought into competition that were able to do such very good work, and also at witnessing the friendly, straightforward, and honourable way in which the exhibitors of the respective machines met on this occasion.—Signed, on behalf of the jury, W. F. WHARTON, Foreman.

"Mr. Robinson's Report on Question 6.—'Having carefully examined both machines, and given the subject due consideration, I am of opinion that M'Cormick's reaping-machine, as at present made, is most liable to get out of order. Signed, THOMAS ROBINSON.

"'York, September 30, 1851.'"

After the trial, Hussey's machine was placed in the hands of Mr. Fawcitt, of Ormesby, that he might work it on his own farm, and thus test its fitness for every-day work, especially when in the hands of strangers. Mr. Fawcitt speaks highly of its performance, and after very little practice made as good or better work with it than Mr. Hussey himself. The proprietors of the two machines were subsequently invited to attend the meeting of the Barnard Castle Agricultural Society. This invitation was declined by the proprietors of M'Cormick's machine, but accepted by Mr. Hussey, and great pains were taken to make the trial such as to fairly test the fitness of the machine for ordinary harvest work. The barley on which it was first tried was a light crop, a good deal bent down in one direction, but not laid flat or twisted about, so that it was considered a favourable opportunity for cutting by machine. The machine was driven round a square piece of corn. It cut extremely well when working either against or across the lay of the corn, *i. e.* on three sides of the square; but when cutting the fourth side, the corn, which was short in the straw, was so much bent from the cutting knives by a strong west wind which was blowing at the time, that it was necessary to drive it at a smart pace to avoid passing over it uncut; and after a few rounds it was thought better to cut three sides only, and let the machine go empty along the fourth. The barley was closely and evenly cut, the stubble being left from five to six inches in length. One or two persons were sent into the corn, to trample it down and twist it about. This did not interfere with the working of the machine, and the twisted corn was well cut in all cases in which it was not trodden so close to the ground that the machine passed over it. In one low part of the field the barley was thin, and a complete mat of grass and other weeds covered the ground. This was extremely well cut, so much so as to encourage the hope that this machine may on level land be made applicable to the cutting of grass. In another part of the field the barley was heavy, and laid flat, grass and weeds having grown up among it; there the machine failed, and it was questionable whether even scythes could have made anything of it, it being one of those places where sickles alone could make good work. It was subsequently tried on oats, with similar results, and on the following day it cut 4 acres of wheat in about 2½ hours.

When the machine was carefully driven it was found that a breadth of 4 feet 10 inches was cleared at each turn, but when no especial attention was paid to this point it cut from 4 to 4½ feet, which was quite as much as was cleared by M'Cormick's during the trial at Ormesby. With moderately careful driving, the latter width (4 feet 6 inches) may be taken as the average, and, if the machine progressed without interruption at the rate of 2 miles an hour, 1 acre would be cut

down in 55 minutes, or about 13 acres in 12 hours. The extent of interruption that would occur would of course vary according to the state of the crop. In some cases it will probably be found advisable to cut one way only and return empty, in others to cut round a field, whilst a third method, which would probably be more generally applicable than either of the other two, would be to set out the field in breaks in the same way that broad flat lands are set out for ploughing, and to work the machine as a plough would be worked, down one side of the break, and up the other. But in whatever way it may be worked it will be easy for any one to calculate the rate at which he is getting through his work if he bear in mind that when his horses are walking two miles an hour he is cutting at the rate of an acre in 55 minutes, and he must make his own additions and subtractions for stoppages or increased pace. During the trial at Barnard Castle, Mr. Fawcitt, the tenant farmer who had worked Hussey's machine for some days on his own farm, was requested to take sole charge of it for a time, which he was kind enough to do, and it was highly satisfactory to the agriculturists present to observe that he cleared the corn off the stage with great facility, and that the work was done with quite as great precision as when Mr. Hussey himself had charge of the machine.

After witnessing the above trials the practical men present were generally convinced that both Hussey's and M'Cormick's machines were well adapted for English husbandry, and that to work them successfully no such skill or knowledge of machinery was required as to make them unfit for general use. M'Cormick's machine, as at present adjusted, cuts too high, but this may be remedied by introducing the power of raising or lowering the axle according to the nature of the work. The main difference between the working of the two machines is, that one delivers the corn at the side, the other at the end; and as this is a point of importance, and arises from the difference in the cutting principles introduced into the two machines, it is necessary to explain the point somewhat in detail. In M'Cormick's machine the cutting surface consists of a long serrated knife (or series of knives), whose edge forms a straight line at right angles to the line of draught, so that it directly meets the crop to be cut, and requires a certain amount of resistance in the corn itself; otherwise it will press it down and pass over it. Where the corn has a decided lean in one direction, this machine, if worked against the lay of the straw, meets with the requisite resistance, and cuts it extremely well; but where the corn is upright, it is necessary to use artificial means to keep the corn up to the cutting knives whilst it is sawing through it. This is accomplished by means of the revolving vanes or fanners, which bend the corn towards the knife, and in this way a standing crop also is well cut.

In Hussey's machine the cutting surface consists of a number of small knives, in shape bearing considerable resemblance to the heads of arrows or javelins. These knives pass rapidly backwards and forwards between projecting bosses of similar shape, which act as sheaths to the knives when at rest, and as stays to the corn when at work. The cutting action of these knives resembles in appearance the action of shears, but when closely examined it approaches more nearly to the principle commonly used in chaff-cutters, where a sharp knife passes close to a metal plate, the knife being so arranged as to have a drawing cut, and the metal plate giving the requisite stiffness to the straw or other material operated on. It will thus be seen that this machine does not require any firmness in the substance to be cut, but anything which gets between the projecting bosses must be cut by the knives, whether it be stiff like straw or yielding like clover or grass, the requisite support being given by the edge of the boss against which the straw or grass is pressed by the returning knife.

It has already been stated that M'Cormick's machine makes good

work when the corn is either upright or leaning towards it, and if Hussey's were not intended to do more than this there would be no impediment in the way of his delivering the corn at the side; in fact he has an additional board to put on for this purpose. Mr. Hussey, however, aims at cutting corn in almost every position, and for this purpose he employs a rake of peculiar form, which is used by the man on the machine to raise the corn when laid in such a position that the machine would be liable to pass over it, and, as has been already shown, when once between the knives it is sure of being cut. This rake, though adapted for the double purpose of raising the corn to the knife and delivering it at the back, could not be used for delivery at the side. If, therefore, it be wished to retain the power of raising with the rake such corn as is twisted about or laid in an awkward position, and also to have the corn delivered at the side, it would be necessary to have two men on the machine, each provided with a rake for his own peculiar work. As this causes some additional expense, it becomes necessary to inquire whether the advantages contemplated by this arrangement are of sufficient importance to justify it. On this point there will probably be some difference of opinion. Mr. Fawcitt, who worked the machine on his farm for a week or ten days, found no inconvenience from the delivery behind, but in those parts of the country where barley and oats are not considered worth tying up, but are carted and stacked like hay or straw, it would be quite necessary to have those crops at least delivered at the side. This may be done without an additional hand, if the rake be dispensed with which lifts and gathers the corn to the knives.

The final question, therefore, to decide is, what advantage is obtained by this lifting process. Here again some difference of opinion may be anticipated. Those who grow light crops of corn would probably derive little benefit from it except in unusually stormy seasons; but those who are fortunate enough to have heavy ones, know that it is unusual to have their corn either wholly standing or uniformly leaning one way, but that patches of greater or less extent, according to the season, are to be met with where the corn may be said to be laid in all directions. These patches it would be highly inconvenient to leave uncut, as it would necessitate making circuits round patches of all shapes and sizes, which would militate greatly against that regularity and despatch which is so essential in a harvest-field. It would be equally disagreeable to pass over these patches, cutting some of the corn, taking off the heads of more, and trampling the remainder under foot. It is therefore clear that those who grow good crops would employ the scythe in preference to the reaping-machine, unless it were capable of coping with difficulties of this kind. There are doubtless cases where corn is laid so flat that no machine could be expected to cut it, and where even skilful mowers could not avoid making great waste, but under ordinary circumstances, on arriving at a patch of laid and twisted corn, Hussey's rake, properly applied, raises the corn sufficiently to enable the knives to lay hold of it. In this respect the plan adopted by Hussey is superior to that of M'Cormick, as when corn is much laid the fanners of the latter machine do not touch it, and yet from their position they prevent the rake being used. On the whole, Hussey's machine seems best adapted to cut corn under a variety of circumstances, or, in ordinary phraseology, to *take it as it comes.* It must, however, be left for further experience to decide whether each machine may not have its own peculiar excellencies, and consequently its own sphere of usefulness.

H. S. Thompson.

Moat Hall, October 28.

Awards of Medals. Class IX.

1. PREPARATION OF LAND.

				£.	s.	d.
1.	Subsoil Plough	Bentall	*nr. Maldon.*		—	
2.	Two-Horse Ploughs	Ball	*nr. Kettering*	4	4	0
		Busby	*Bedale*	4	7	6
		Howard	*Bedford*	4	0	0
		Deltouche	*Belgium.*		—	
		Odeurs	*Belgium.*		—	
		Talbot	*France.*		—	
		Jenken	*Holland.*		—	
		Prouty	*United States.*		—	
	Four-Horse Ploughs	Busby	*Bedale*	4	10	0
		Hensman	*Woburn*	4	5	0
		Howard	*Bedford*	4	11	6
3.	Harrows—Expanding	Coleman	*Chelmsford*	4	0	0
		Howard	*Bedford*	4	11	6
	,, Light	Williams	*Bedford*	4	4	0
	,, Heavy	Williams	*Bedford*	5	0	0
4.	Cultivators—Wide	Coleman	*Chelmsford*	13	0	0
		Ransome and May	*Ipswich*	18	18	0
	,, Narrow	Bentall	*nr. Maldon*	6	6	0
5.	Roller	De Claes	*Belgium.*		—	
6.	Clodcrusher	Crosskill	*Beverley*	16	10	0
		Gibson	*Newcastle-on-T.*	15	10	0
	Norwegian Harrow	Crosskill	*Beverley*	13	0	0

2. CULTIVATION OF CROPS.

				£.	s.	d.
1.	Ribbing Corn-Drill	Busby	*Bedale*	18	18	0
	Small Corn-Drill	De Claes	*Belgium.*		—	
	General-purpose Drill	Garrett	*Saxmundham*	35	12	6
	Turnip-Drill on the Flat	Garrett	*Saxmundham*	23	10	0
	Hand-Drill for Seeds	Garrett	*Saxmundham*	5	5	0
	Corn and Seed Drill	Hensman	*Woburn*	22	0	0
	Corn and Seed Drill	Hornsby	*Grantham*	31	10	0
	Drop-Drill	Hornsby	*Grantham*	24	0	0
	Turnip-Drill on Ridge	Hornsby	*Grantham*	24	0	0
	Corn Distributor	Ransome and May	*Ipswich*	31	10	0
	Water-Drill	Reeves	*nr. Westbury*	25	0	0

			£.	s.	d.
2. CULTIVATION OF CROPS—*continued.*					
2. Topdresser	Dr. Newington	*Hastings.*		—	
Liquid-manure Cart	Reeves	*nr. Westbury*	16	0	0
3. Horsehoe—Narrow	Busby	*Bedale*	2	10	0
,, Narrow	Comins	*South Molton*	3	0	0
,, Wide	Garrett	*Saxmundham*	15	0	0
3. HARVESTING OF CROPS.					
1. Reaper	M'Cormick	*United States*	25	0	0
		Burgess and Key, London.			
2. Horse-Rake	Howard	*Bedford*	7	0	0
	Smith	*Stamford*	6	15	0
3. Haymaker	Smith	*Stamford*	14	14	0
4. One-Horse Carts	Busby	*Bedale*	12	10	0
	Crosskill	*Beverley*	12	10	0
	Crowley	*Newport Pagnell*	14	0	0
	Gray	*Uddingstone, N.B.*	12	12	0
4. PREPARATION FOR MARKET.					
1. Moveable Steam-engines	Barrett and Exall, 4-horse	*Reading*	167	0	0
	Clayton and Shuttleworth, 6-horse	*Lincoln*	195	0	0
	Garrett, 5-horse	*Grantham*	205	0	0
	Hornsby, 6-horse	*Saxmundham*	205	0	0
	Tuxford, 6-horse	*Boston*	195	0	0
2. Threshing Machines	Hensman	*Woburn*	68	0	0
	Holmes	*Norwich*	56	0	0
	Garrett	*Saxmundham*	60	0	0
3. Corn-Dresser	Hornsby	*Grantham*	13	10	0
4. Corn-Cleaner	Vachon	*France.*		—	
5. PREPARATION OF FOOD FOR STOCK.					
1. Chaff-Cutters	Cornes	*nr. Nantwich*	14	0	0
	Garrett	*Saxmundham*	14	0	0
	Smith and Co.	*Stamford*	14	0	0
2. Turnip-Cutters	Burgess and Key	103, *Newgate St., London*	5	0	0
	Samuelson	*Banbury*	5	0	0
3. Cake-Bruisers	Hornsby	*Grantham*	5	5	0
	Nicholson	*Newark-on-Trent*	5	5	0
4. Linseed & Corn-crushers	Barrett and Exall	*Reading*	6	6	0
	Stanley	*Peterborough*	12	0	0
5. Meal Mills, *American*	Crosskill	*Beverley*	28	0	0
	Hurwood	*Ipswich*	21	0	0
6. Gorse-bruiser	Burrell	*Thetford*	27	10	0

6. MISCELLANEOUS.

			£.	s.	d.
CHURNS—American	Burgess and Key	*London*	1	17	6
„ Belgian	Du Chêne	*Belgium.*		—	
„ French	Lavoisie	*France.*		—	
„ English	Wilkinson	309, *Oxford St.*	2	0	0
DYNAMOMETER	Bentall	*nr. Maldon.*		—	

7. DRAINING.

TILE-MACHINES	Clayton	*Dorset Sq.*	25	0	0
	Scragg	*Tarporley*	30	0	0
	Whitehead	*Preston*	21	0	0

HONOURABLE MENTION.

DRAINING PLOUGH	Fowler	*Melksham*	150	0	0

COUNCIL MEDALS.

Busby.
Crosskill.
Garrett.
Hornsby.
M'Cormick.

N.B. The Names of the Manufacturers are placed under each head alphabetically.

As the various Machines of the same denomination are of different sizes, and include often a different amount of extras, the prices stated are merely approximative, and cannot be taken as a standard for decision by purchasers.

END OF VOLUME XII.

LONDON: PRINTED BY W. CLOWES AND SONS, DUKE-STREET, STAMFORD-STREET.

Royal Agricultural Society of England.

1851—1852.

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Stansfield, W. R. Crompton, M.P.
Thompson, Henry Stephen
Turner, Charles Hampden
Turner, George
Webb, Jonas
Wilson, Henry

Secretary.

JAMES HUDSON, 12, *Hanover Square, London.*

Consulting-Chemist—JOHN THOMAS WAY, 23, Holles Street, Cavendish Square.
Veterinary-Inspector—JAMES BEART SIMONDS, Royal Veterinary College.
Consulting-Engineer—JAMES EASTON, or C. E. AMOS, The Grove, Southwark.
Seedsmen—THOMAS GIBBS and Co., Corner of Halfmoon Street, Piccadilly.
Publisher—JOHN MURRAY, 50, Albemarle Street.
Bankers—H., A. M., C., A. R., G., and H. DRUMMOND, Charing Cross.

General Meetings in 1851-2.

The General December Meeting, in London, on Saturday, December 13th, 1851.

The General May Meeting, in London, on Saturday, May 22, 1852.

The Annual Country Meeting, at Lewes, in Sussex, in 1852.

Annual Subscriptions.

Subscriptions may be paid to the Secretary, in the most direct and satisfactory manner, either at the Office of the Society, No. 12, Hanover-Square, London, between the hours of ten and four, or by means of Post-Office orders, to be obtained on application at any of the principal Post-Offices throughout the kingdom, and made payable to him at the General Post-Office, London; but any cheque on a Banker's, or other house of business in London, will be equally available, if made payable on demand. The subscriptions are due in advance for each year on the 1st of January, and are in arrear if unpaid by the 1st of June ensuing. No Member is entitled to the Journal, or to any other privilege of the Society, whose subscription is in arrear.

Essays and Reports.

All Essays and Reports competing for the Prizes of the Society in this department for next year, are to be sent to the Secretary, 12, Hanover Square, London, on or before the 1st of March, 1852, with the exception of those competing for the Prize for the Essay on Guano, which need not be sent in until on or before March 1, 1854.

Royal Agricultural Society of England.

GENERAL MEETING,

12, Hanover Square, Thursday, May 22, 1851.

REPORT OF THE COUNCIL.

The Council have to report that since their last general meeting in December, the Society has been deprived by death of 65 of its members, including Sir Francis Lawley, Bart., one of the founders and trustees of the Society, and the Hon. Captain Pelham, a member of the Council, and one of the stewards of implements at the Country Meetings of the Society; 216 names have also been removed from the list, while 163 new members have been elected during the half-year: the Society accordingly now consists of—

91 Life Governors,
162 Annual Governors,
674 Life Members,
4175 Annual Members, and
19 Honorary Members;

making a total of 5121 general members on the list of the Society at the present time.

The Council have transferred the name of Colonel Challoner from the general members of Council to the class of Trustees of the Society, to fill the vacancy in that list occasioned by the decease of Sir Francis Lawley; and they have elected Mr. Pendarves, M.P., into the Council, to complete the required number of their members.

The chemical investigations are proceeding in a satisfactory manner, and the subject of the absorptive properties of clay soils

in reference to manuring matter continues to receive from Professor Way the attention which its importance demands. The torrefaction of soils, or burning of clays, for the purpose of effecting a beneficial change in their mechanical condition and physical properties, has been selected by the Chemical Committee as the new subject for investigation on the completion of the analysis of marls; and the Council hope that members residing in districts where such process is adopted with success, will take an early opportunity of sending to the Secretary specimens of such fertilizing clays, in their natural as well as in their burnt state, along with a statement of any facts within their knowledge connected therewith. As Consulting-Chemist of the Society, Professor Way has spontaneously offered to reduce his charges to the lowest possible scale for making analyses of guano for the members; and as the Council consider a special analysis of that manure to be the only safeguard against the attempts at fraud so extensively practised by unprincipled dealers, they trust that the members of the Society will avail themselves of so cheap, simple, and effective a means of security.

The Council have decided to renew the grant of 200*l.* to the Royal Veterinary College, for the year, for the purpose of aiding that institution in carrying out one of the original objects of the Society, namely, "the improvement of the veterinary art, as applied to cattle, sheep, and pigs:" such renewal being made under the following conditions:—1. That all members of the Royal Agricultural Society of England shall have the privilege of sending cattle, sheep, and pigs to the Royal Veterinary College on the same terms as if they were subscribers to it; and 2. That the Royal Veterinary College make a report at the end of the year of their proceedings in connexion with this grant.

During the past half-year the Council have made such alterations in their bye-laws as will restrict the official business more completely to the monthly meetings, in order that the weekly meetings may be given up entirely to short introductory lectures, leading to subsequent discussion and the communication of personal experience among the members, on topics connected with

practical farming. Professor Way and Professor Simonds have each expressed their willingness to take such part in these proceedings as the Council may from time to time think desirable, and will make arrangements accordingly.

On a former occasion the Council reported to the members the offer of a site in Hyde Park for the Society's agricultural show of breeding stock: the conditions for the occupation of that site, however, which were subsequently submitted to the Council by the Commissioners of Woods and Forests, were such as the Council, acting on the part of the Society, could not accept. The first minister of the Crown then expressed his desire to promote the objects of the Society by the offer of a site to which, from its locality, no such conditions as those necessarily required in the case of Hyde Park would apply. Accordingly her Majesty's consent on his Lordship's representation was at once given for the Society to select a site in such one of the Royal parks of Hampton Court, Bushy, or Kew, as might be found on inspection most suitable for the purposes of the Society. The Council, in pursuance of this offer, decided to select a site in Bushy Park, and were placed by the Government in communication with the Commissioners of Woods and Forests and the Master of the Horse, when the authorities of Windsor informed the Council of the gracious permission of her Majesty, and that of his Royal Highness Prince Albert, to place the Home Park of that royal demesne at the disposal of the Society, as a site for the purposes of that country meeting, should the Council consider it preferable to the one already selected in Bushy Park. The Council, on the report of the same Committee of Inspection that visited Bushy Park, decided that the country meeting of the present year should be held in the Home Park at Windsor, agreeably with the permission thus so graciously conceded to the Society: a permission which the members of the Society will not fail to regard as not only most gratifying in itself, but as enhanced in its value by the prompt and condescending manner in which it has been communicated.

The attractiveness of the Home Park as a site for the meeting,

and its immediate contiguity to the Great Western and South Western Railways, will no doubt tend to the access and accommodation of a larger number of visitors than have attended on any former occasion. Notwithstanding the short period during which the Mayor and Corporation of Windsor had on this occasion an opportunity of making arrangements for the Society's reception at a place of meeting to which they had invited its Members, the Council have the pleasure of stating that those arrangements have been completed most satisfactorily, as in the case of other places where the Country Meetings of the Society have been held, the Mayor of Windsor, in the name and on behalf of himself and the Corporation, having entered into guarantees with the Commissioners of Woods and Forests, by which the Society will, agreeably with the Royal Permission, be granted the full and free occupation of the site selected in the Home Park for the purposes of the Meeting, and be held harmless from all liability of damage and from all charges of occupation. The Mayor and Corporation have also placed the sum of £600 to the credit of the Society's account with Messrs. Drummond, as a subscription from the town and neighbourhood of Windsor, intended to meet to that extent the heavy expenses which the Society always incurs in the preparations for its Country Meeting. The week of the Society's Country Meeting at Windsor will commence on Monday, the 14th of July next. The Show, as ascertained from the entries made, will consist of upwards of twelve hundred head of breeding stock, and will be open to the public on the Tuesday, Wednesday, and Thursday; and the dinner of the Society will take place on the Home Park, on the Wednesday of the same week, in a pavilion constructed to contain 2,000 guests. Members of the Society who apply to the Secretary for their Pavilion Dinner Tickets between the 20th June and the 5th July, will receive them on the usual conditions. The Council have nearly completed with the principal railway companies throughout the kingdom the arrangements for the conveyance of the stock to and from the Show: and in every case where they have at present received a decision, a free transit has been granted to the Stock

entered for the Windsor Meeting, both to and from the Show; and they have every reason to believe that the same liberal concessions in favour of the Society's Exhibitors, for the purpose of promoting the objects of the Society, will, as in former years, be conceded by the other Railway Companies to whom they have also applied. The Council have taken measures for obtaining a greater number of nominations from which to select the Judges for the Country Meetings; but they still feel the imperfection of all plans hitherto adopted for their appointment. The Council duly appreciate the great importance of a strict and impartial adjudication of the Society's prizes, by men not only disinterested in themselves, but fully qualified by their abilities and experience for the arduous task confided to them; and the Council will esteem it a favour if the Members of the Society at large will from time to time transmit to them any suggestions that may tend to promote this desirable object, and essentially to give effect to that competition for excellence which the Society, by its premiums, evinces so great a wish to excite. They have already referred it to the Judges, as part of their duty, to ascertain and report to the Council any failure in the due shearing of the sheep, or any excess in the market-condition of the animals inconsistent with their character as breeding stock. They consider that the higher the character of their Judges becomes, the more powerfully will they be able to aid the Council in repressing many of the abuses alleged to take place in the competition for prizes. They also hope that the time is not far distant when the judgments given in the Show-yard, in the case of Live Stock, will be founded on well-defined and acknowledged principles, having reference, in each class, to some assigned standard of excellence: and that these judgments, although formed on less distinct and constant data than in the case of implements, may gradually approximate in some degree to uniform and consistent results, that may prove, like those in the implement yard, satisfactory, at the same time, both to the Judges and the competing Exhibitors; and thus tend to establish those points of form, development, and quality which constitute perfection of breed in

the different classes of animals adapted for agricultural purposes.

The Council have selected Lewes as the place of the Country Meeting of the Society for the year 1852; and they have at the same time constituted a new district for the Country Meeting four years in advance from the present time, agreeably with their usual practice. The rotation of districts, therefore, now stands as follows :—

1852—South-Eastern District, comprising the counties of Kent, Surrey, and Sussex.

1853—South-Wales District, comprising the whole of South Wales, with the addition of the counties of Gloucester, Hereford, Monmouth, and Worcester.

1854—East-Midland District, comprising the counties of Leicester, Lincoln, Nottingham, and Rutland.

1855—North-Western District, comprising the counties of Lancaster, Westmoreland, and Cumberland, and the Isle of Man.

The Council, in conclusion, have every reason to congratulate the Members on the continued prosperity of the Society, and on the undeviating manner in which it steadily pursues those practical objects connected with the improvement of land, the management of crops, and the general advancement of good husbandry, in which all its Members are more or less deeply interested.

By order of the Council,

(Signed) JAMES HUDSON,
Secretary.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

Half-yearly Account, ending the 31st of December, 1850.

Receipts.

	£.	s.	d.
Balance in the hands of the Bankers, 1st July, 1850	2435	3	8
Balance in the hands of the Secretary, 1st July, 1850	19	17	3
Dividends on Stock	160	6	1
Life-Composition of Governor	50	0	0
Life-Compositions of Members	239	0	0
Annual Subscriptions of Governors	85	0	0
Annual Subscriptions of Members	1508	17	0
Receipts on account of Journal	234	13	0
South-Devon Prizes	50	0	0
Receipts on account of Country Meetings	1143	2	11
	£ 5925	19	11

(Signed) THOMAS RAYMOND BARKER, *Chairman*, C. B. CHALLONER, THOMAS AUSTEN, } *Finance Committee.*

Payments.

	£.	s.	d.
Permanent Charges	178	12	6
Taxes and Rates	13	15	2
Establishment	422	13	0
Postage and Carriage	20	8	6
Advertisements	13	8	0
Law Expenses	99	5	5
Payments on account of Journal	740	14	7
Chemical Grant	100	0	0
Chemical Investigations	100	0	0
Veterinary Inspection	12	12	0
Prizes of the Society	1517	14	6
South-Devon Prizes	50	0	0
Payments on account of Country Meetings	1903	15	1
Sundry Items of Petty Cash	3	9	5
Balance in the hands of the Bankers, 31st December, 1850	738	2	8
Balance in the hands of the Secretary, 31st December, 1850	11	9	1
	£ 5925	19	11

Examined, audited, and found correct, this 16th day of May, 1851.

(Signed) THOMAS KNIGHT, ROBERT BEMAN, GEO. I. RAYMOND BARKER, } *Auditors on the part of the Society.*

Country Meeting at Windsor.

JULY 14—18, 1851.

JUDGES.

SHORT HORNS.	THOMAS PARKINSON	Leyfields, Nottinghamshire.
	JOHN WRIGHT	Chesterfield, Derbyshire.
	JAMES TOPHAM	Candlesby, Lincolnshire.
HEREFORDS.	WM. FISHER HOBBS	Boxtead Lodge, Essex.
	HENRY CHAMBERLAIN	Desford, Leicestershire.
	THOMAS TOWNSEND	Hillmorton Hall, Warwickshire.
DEVONS.	HENRY TRETHEWY	Grampound, Cornwall.
	THOMAS REYNOLDS	Sandford, Devonshire.
	WILLIAM BULLEN	Wayford, Somersetshire.
OTHER BREEDS.	JOHN CLAYDEN	Littlebury, Essex.
	JAMES WALKER	Suttie, Aberdeenshire.
	WILLIAM COX	Scotsgrove, Buckinghamshire.
HORSES.	JOHN HANNAM	Kirk Deighton, Yorkshire.
	WILLIAM GREAVES	Matlock-Bath, Derbyshire.
	JOHN RINDER KIRKHAM	Andleby, Lincolnshire.
LEICESTER SHEEP.	JOSEPH ALLISON	Bilby, Nottinghamshire.
	VALENTINE BARFORD	Foscote, Northamptonshire.
	NATHANIEL C. STONE	Rowley Fields, Leicestershire.
SOUTH-DOWN SHEEP.	EDWARD POPE	Great Toller, Dorsetshire.
	PETER PURVES	Alconbury, Huntingdonshire.
	THOMAS WEALL	Rickmansworth, Hertfordshire.
LONG-WOOLLED SHEEP.	ROBERT BEMAN	Moreton-in-the-Marsh, Gloucestershire.
	JOHN CLARKE	Long Sutton, Lincolnshire.
	EDWARD CLARKE	Canwick, Lincolnshire.
MOUNTAIN SHEEP.	JOHN CLAYDEN	Littlebury, Essex.
	JAMES WALKER	Suttie, Aberdeenshire.
	WILLIAM COX	Scotsgrove, Buckinghamshire.
PIGS.	WILLIAM HESSELTINE	Worlaby House, Lincolnshire.
	BENJAMIN SWAFFIELD	Chatsworth, Derbyshire.
	WILLIAM TINDALL	Wheately, Yorkshire.

VETERINARY INSPECTOR,

AND REFEREE TO THE JUDGES.

PROFESSOR SIMMONDS......Royal Veterinary College, London.

AWARD OF PRIZES.

Cattle: I. *Short-Horns.*

Thomas Wetherell, of Kirkbridge, near Darlington, Durham: the Prize of Forty Sovereigns, for his 4 years and 9 months-old Short-horned Bull; bred by Henry Lister Maw, of Tetley, near Crowle, Lincolnshire.

Lord Hastings, of Melton Constable, near Thetford, Norfolk: the Prize of Twenty Sovereigns, for his 6 years and 1 month-old Short-horned Bull; bred by himself.

John Kirkham, of Hagnaby, near Spilsby, Lincolnshire: the Prize of Twenty-Five Sovereigns, for his 2 years 4 months and 8 days-old Short-horned Bull, bred by himself.

Thomas Raine, of Gainford, near Darlington, Durham: the Prize of Fifteen Sovereigns, for his 2 years and 3 months-old Short-horned Bull; bred by himself.

Thomas Bentley, of Pannal Hall, Pannal, near Wetherby, Yorkshire: the Prize of Ten Sovereigns, for his 1 year and 10½ months-old Short-horned Bull; bred by F. H. Fawkes, of Farnley Hall, near Otley, Yorkshire.

Richard Booth, of Warlaby, near Northallerton, Yorkshire: the Prize of Twenty Sovereigns, for his 4 years and 4 months-old Short-horned In-calf and In-milk Cow; bred by himself.

Viscount Hill, of Hawkstone, near Shrewsbury: the Prize of Ten Sovereigns, for his 6 years 1 month and 24 days-old Short-horned In-milk Cow; bred by himself.

Charles Towneley, of Towneley Park, near Burnley, Lancashire: the Prize of Twenty Sovereigns, for his 2 years and 2 months-old Pure Short-horned In-calf Heifer; bred by himself.

Charles Towneley, of Towneley Park, near Burnley, Lancashire: the Prize of Fifteen Sovereigns, for his 2 years and 9 months-old pure Short-horned In-calf Heifer; bred by Richard Eastwood, of Swinshow, near Burnley, Lancashire.

James Douglas, of Athelstaneford, New Mains, near Drem, Haddingtonshire: the Prize of Ten Sovereigns, for his 2 years and 1 month-old Short-horned In-calf Heifer; bred by Mr. Turner, of Killcullen.

Viscount Hill, of Hawkstone, near Shrewsbury: the Prize of Fifteen Sovereigns, for his 1 year 10 months and 16 days-old Short-horned yearling Heifer, bred by himself.

Henry Ambler, of Watkinson Hall, near Halifax, Yorkshire: the Prize of Ten Sovereigns, for his 1 year and 6 months-old Short-horned yearling Heifer; bred by himself.

Viscount Hill, of Hawkstone, near Shrewsbury: the Prize of Five Sovereigns, for his 1 year 10 months and 23 days-old Short-horned yearling Heifer; bred by himself.

Cattle: II. *Herefords.*

Lord Berwick, of Cronkhill, near Shrewsbury: the Prize of Forty Sovereigns, for his 4 years 6 months and 23 days-old Hereford Bull; bred by Thomas Longmore, of Walford.

Edward Price, of The Court House, Pembridge, near Leominster, Herefordshire: the Prize of Twenty Sovereigns, for his 3 years and 20 days-old Hereford Bull, bred by himself.

Fowler Boyd Price, of Huntington, near Hereford: the Prize of Twenty-five Sovereigns, for his 1 year and 10 months-old Hereford Bull; bred by the late John Jones, of Lower Breinton, near Hereford.

Sylvanus Archibald, of Holmer, near Hereford: the Prize of Fifteen Sovereigns, for his 1 year and 10 months-old Hereford Bull, bred by himself.

John Monkhouse, of The Stow, near Hereford: the Prize of Ten Sovereigns, for his 1 year and 10½ months-old Hereford Bull; bred by himself.

Lord Berwick, of Cronkhill, near Shrewsbury: the Prize of Twenty Sovereigns, for his 3 years 8 months and 28 days-old Hereford In-milk Cow; bred by himself.

Rev. John Robert Smythies, of East Hill, near Colchester, Essex: the Prize of Ten Sovereigns, for his 4 years and 6 months-old true Hereford In-milk and In-calf Cow; bred by Samuel Aston, of Lynch Court, near Leominster, Herefordshire.

Lord Berwick, of Cronkhill, near Shrewsbury: the Prize of Twenty Sovereigns, for his 2 years 8 months and 19 days-old Hereford In-calf Heifer; bred by himself.

Lord Berwick, of Cronkhill, near Shrewsbury: the Prize of Fifteen Sovereigns, for his 2 years 7 months and 14 days-old Hereford In-calf Heifer; bred by himself.

Philip Turner, of The Leen, Pembridge, near Leominster, Herefordshire: the Prize of Ten Sovereigns, for his 2 years and 9 months-old Hereford In-calf Heifer; bred by himself.

Fowler Boyd Price, of Huntington, near Hereford: the Prize of Fifteen Sovereigns, for his 1 year and 9 months-old Hereford yearling Heifer; bred by John Nelson Carpenter, of Eardisland, near Leominster.

Walter Maybery, of Penlan, near Brecon: the Prize of Ten Sovereigns, for his 1 year and 8 months-old Hereford yearling Heifer; bred by himself.

Lord Berwick, of Cronkhill, near Shrewsbury: the Prize of Five Sovereigns, for his 1 year 7 months and 16 days-old Hereford yearling Heifer; bred by himself.

Cattle: III. *Devons.*

John Quartly, of Champson Molland, near South Molton, Devon: the Prize of Forty Sovereigns, for his 3 years and 5 months-old North Devon Bull; bred by himself.

James Davy, of North Molton, near South Molton, Devon: the Prize of Twenty Sovereigns, for his 5 years and 10 weeks-old pure Devon Bull; bred by himself.

Samuel Farthing, of Stowey Court, near Bridgewater, Somerset: the Prize of Twenty-five Sovereigns, for his 2 years and 6 months-old Devon Bull; bred by himself.

Thomas Miller, of Castle Farm, near Sherborne, Dorset: the Prize of Fifteen Sovereigns, for his 2 years and 4 months-old Devon Bull; bred by himself.

Thomas Bond, of Bishop's Lydeard, near Taunton, Somerset: the Prize of Ten Sovereigns, for his 2 years and 5 months-old Devon Bull; bred by himself.

George Turner, of Barton, near Exeter, Devon: the Prize of Twenty Sovereigns, for his 5 years and 7 months-old pure North Devon In-milk and In-calf Cow; bred by the late Mr. Tremlett, of Cheriton, Devon.

Frederick Hogg, of 40, St. James's-street, London: the Prize of Ten Sovereigns, for his 7 years and 3 months old pure Devon In-milk Cow; bred by Matthew Paull, of Burstock Grange, near Broadwinsor, Dorset.

George Turner, of Barton, near Exeter, Devon: the Prize of Twenty Sovereigns, for his 2 years and 3 months-old pure North Devon In-calf Heifer; bred by himself.

George Turner, of Barton, near Exeter, Devon: the Prize of Fifteen Sovereigns, for his 2 years and 6 months-old pure North Devon In-calf Heifer; bred by himself.

The Earl of Leicester, of Holkham Hall, near Wells-next-the-Sea, Norfolk: the Prize of Ten Sovereigns, for his 2 years and 9 months-old pure North Devon In-calf Heifer; bred by Lord Portman, of Bryanston, near Blandford, Dorset.

William M. Gibbs, of Bishop's Lydeard, near Taunton, Somersetshire: the Prize of Fifteen Sovereigns, for his 1 year and 9 months-old Devon yearling Heifer; bred by himself.

John Quartly, of Champson Molland, near South Molton, Devon: the Prize of Ten Sovereigns, for his 1 year and 5 months-old North Devon yearling Heifer; bred by himself.

George Turner, of Barton, near Exeter, Devon: the Prize of Five Sovereigns, for his 1 year and 7 months-old pure North Devon yearling Heifer; bred by himself.

Cattle: IV. *Other Breeds* (not qualified to compete as Short-horns, Herefords, or Devons).

Long Horns.

[The Prize of Ten Sovereigns offered by the Society for the best Bull calved previously to the 1st of January, 1849, was withheld by the Judges.]

Richard H. Chapman, of Upton, near Atherstone, Warwickshire: the Prize of Ten Sovereigns, for his 2 years and 4½ months-old Long-horned Bull; bred by himself.

Thomas Beards, of Stowe, near Buckingham; the Prize of Ten Sovereigns, for his 4 years and 11 months-old Long-horned In-milk Cow; bred by himself.

Thomas Beards, of Stowe, near Buckingham: the Prize of Five Sovereigns, for his 2 years and 10 months-old Long-horned In-calf Heifer; bred by himself.

Thomas Beards, of Stowe, near Buckingham: the Prize of Five Sovereigns, for his 1 year and 8 months-old Long-horned yearling Heifer; bred by himself.

Channel Islands.

The Earl of Egmont, of Cowdray, near Petworth, Sussex: the Prize of Ten Sovereigns, for his 3 years and 13 days-old Channel Islands' Bull; bred by himself.

John Gregory Watkins, of Woodfield, near Worcester: the Prize of Ten Sovereigns, for his 2 years and 4 months-old Channel Islands' Bull; bred by himself.

George Torode, of The Forest Parish, Guernsey: the Prize of Ten Sovereigns, for his 3 years and 6 months-old pure Guernsey In-calf Cow; bred by Peter Le Page, of St. Martin's, Guernsey.

Sir John Cathcart, Bart., of Cooper's Hill, Chertsey, Surrey: the Prize of Five Sovereigns, for his 2 years-old Alderney In-calf Heifer; breeder unknown.

William Henry Chapman, of Wraysbury, near Staines, Middlesex: the Prize of Five Sovereigns, for his 1 year and 6 months-old Alderney yearling Heifer; bred by W. Levi, of Woughton on the Green, near Newport Pagnel, Bucks.

Sussex.

Henry Catt, of West Firle, near Lewes, Sussex: the Prize of Ten Sovereigns, for his 3 years and 5 months-old Sussex Bull; bred by himself.

John Waters, of Motcomb, near Eastbourne, Sussex: the Prize of Ten Sovereigns, for his 1 year and 3 months-old Sussex Bull; bred by James Gorringe of Selmeston, Sussex.

Thomas Child, of Michelham, near Hailsham, Sussex: the Prize of Ten Sovereigns, for his 6 years and 5 months-old Sussex In-milk Cow; bred by himself.

William Marshall, of Bolney Place, near Cuckfield, Sussex; the Prize of Five Sovereigns, for his 2 years and 3 months-old Sussex In-calf Heifer; bred by himself.

William Marshall, of Bolney Place, near Cuckfield, Sussex: the Prize of Five Sovereigns, for his 1 year and 5 months-old yearling Heifer; bred by himself.

Scotch Horned.

[No entry was made for the Prize of Ten Sovereigns offered by the Society for the best Bull calved previously to the 1st of January, 1849.]

Charles Fielder, of Sparsholt, near Winchester, Hants: the Prize of Ten Sovereigns, for his 1 year 3 months and 13 days-old pure Ayrshire Bull; bred by David Glen, of Fletchwood Farm, Eling, near Southampton.

Sir John Cathcart, Bart., of Cooper's Hill, near Chertsey, Surrey: the Prize of Ten Sovereigns, for his 6 years-old Ayrshire In-milk Cow; breeder unknown.

[The Prize of Ten Sovereigns offered by the Society for the best In-calf Heifer was withheld by the Judges.]

[No entry was made for the Prize of Five Sovereigns offered by the Society for the best Yearling Heifer.]

Scotch Polled.

William M'Combie, of Tillyfour, near Alford, Aberdeenshire: the Prize of Ten Sovereigns, for his 5 years and 2 months-old Angus polled Bull; bred by Hugh Watson, of Keillor.

[The Prize of Ten Sovereigns offered by the Society for the best Bull calved since the 1st of January, 1849, was withheld by the Judges.]

ROBERT SCOTT, of Balwyllo, near Montrose, Forfarshire: the Prize of TEN SOVEREIGNS, for his 7 years and 5 months-old pure Aberdeenshire In-calf Cow; bred by Wm. M'Combie, of Tillyfour.

WILLIAM M'COMBIE, of Tillyfour, near Alford, Aberdeenshire: the Prize of TEN SOVEREIGNS, for his 2 years and 5 months-old Angus polled In-calf Heifer; bred by himself.

WILLIAM M'COMBIE, of Tillyfour, near Alford, Aberdeen: the Prize of FIVE SOVEREIGNS, for his 1 year and 5 months-old Angus polled yearling Heifer; bred by himself.

Welsh, Irish, and other Pure Breeds.

LIEUT.-GENERAL SIR EDWARD KERRISON, Bart., of Oakley Park, near Eye, Suffolk: the Prize of TEN SOVEREIGNS, for his 4 years and 1 month-old Suffolk Bull; bred by himself.

GEORGE DAVID BADHAM, of Thurlston, near Ipswich, Suffolk: the Prize of TEN SOVEREIGNS, for his 2 years and 5 months-old Suffolk Bull; bred by himself.

LIEUT.-GENERAL SIR EDWARD KERRISON, Bart., of Oakley Park, near Eye, Suffolk: the Prize of TEN SOVEREIGNS, for his 3 years and 11 months-old Suffolk In-calf Cow; bred by himself.

LIEUT.-GENERAL SIR EDWARD KERRISON, Bart., of Oakley Park, near Eye, Suffolk: the Prize of FIVE SOVEREIGNS, for his 2 years and 11 months-old Suffolk In-calf Heifer; bred by himself.

GEORGE D. BADHAM, of Thurlston, near Ipswich, Suffolk: the Prize of FIVE SOVEREIGNS, for his 1 year and 11 months-old Suffolk yearling Heifer; bred by himself.

HORSES.

THOMAS CATLIN, of Butley, near Woodbridge, Suffolk: the Prize of THIRTY SOVEREIGNS, for his 5 years-old pure Suffolk Agricultural Stallion; bred by himself.

THOMAS CATLIN, of Butley, near Woodbridge, Suffolk: the Prize of FIFTEEN SOVEREIGNS, for his 9 years-old pure Suffolk Agricultural Stallion; bred by himself.

FREDERICK THOMAS BRYAN, of Knossington, near Oakham, Rutlandshire: the Prize of TWENTY SOVEREIGNS, for his 2 years-old Cart Stallion; bred by William Wright, of Stonesby, Leicestershire.

HENRY TAYLER, of Bishopstone, near Faringdon, Berkshire: the Prize of FIFTEEN SOVEREIGNS, for his 2 years-old Cart Stallion; bred by himself.

SAMUEL CLAYDEN, of Little Linton, near Linton, Cambridgeshire: the Prize of TEN SOVEREIGNS, for his 2 years-old Suffolk Agricultural Stallion; bred by himself.

ROBERT BROWN, of Farleigh Wallop, near Basingstoke, Hants: the Prize of TWENTY SOVEREIGNS, for his 6 years-old Dray Stallion; bred by himself.

THOMAS GROVES, of Manor House, Nun Monkton, near York: the Prize of THIRTY SOVEREIGNS, for his 5 years-old thorough-blood Hunter Stallion; bred by Mr. Meicklam, of or near London.

THOMAS HOLTBY, of Brandesburton, near Beverley, Yorkshire: the Prize of THIRTY SOVEREIGNS, for his 5 years-old Coach Stallion; bred by Mr. Whiting, of Hempholme.

Thomas Groves, of Manor House, Nun Monkton, near York: the Prize of Fifteen Sovereigns, for his 6 years-old pure Roadster Stallion; bred either by Captain Viner, of Newby Hall, near Ripon, or by one of his tenants.

John George Sheppard, of the High House, Campsey Ash, near Woodbridge, Suffolk: the Prize of Twenty Sovereigns, for his Suffolk Mare and Foal; the mare bred by himself; the sire of the foal belonged to Nathaniel G. Barthropp, of Cretingham, Suffolk.

John Smith, of Crownthorpe, near Wymondham, Norfolk: the Prize of Fifteen Sovereigns, for his Norfolk Mare and Foal; the mare bred by himself; the sire of the foal belonged to Mr. Cordy, of Shipdham, Norfolk.

William Thompson, of Thorpe-le-Soken, near Colchester: the Prize of Ten Sovereigns, for his Suffolk Mare and Foal; the breeder of the mare unknown; the sire of the foal belonged to himself.

Nathaniel George Barthropp, of Cretingham Rookery, near Woodbridge, Suffolk: the Prize of Twenty Sovereigns, for his 2 years-old Suffolk Filly; bred by Mr. Read, of Laxfield.

Thomas Beale Browne, of Hampen, near Andoversford, Gloucestershire: the Prize of Fifteen Sovereigns, for his 2 years-old Suffolk Filly; bred by himself.

Lord St. John, of Melchbourne, near Higham Ferrers, Northamptonshire: the Prize of Five Sovereigns, for his 2 years-old Cart Filly; bred by himself.

Sheep: I. *Leicesters.*

William Sanday, of Holme Pierrepont, near Nottingham: the Prize of Thirty-five Sovereigns, for his 17 months-old Leicester Ram; bred by himself.

William Sanday, of Holme Pierrepont, near Nottingham: the Prize of Twenty Sovereigns, for his 17 months-old Leicester Ram; bred by himself.

William Sanday, of Holme Pierrepont, near Nottingham: the Prize of Ten Sovereigns, for his 17 months-old Leicester Ram; bred by himself.

Thomas Edward Pawlett, of Beeston, near Biggleswade, Beds: the Prize of Thirty Sovereigns, for his 28 months-old Leicester Ram; bred by himself.

Thomas Edward Pawlett, of Beeston, near Biggleswade, Beds: the Prize of Twenty Sovereigns, for his 40 months-old Leicester Ram; bred by himself.

Thomas Edward Pawlett, of Beeston, near Biggleswade, Beds: the Prize of Ten Sovereigns, for his 40 months-old Leicester Ram; bred by himself.

William Sanday, of Holme Pierrepont, near Nottingham: the Prize of Twenty Sovereigns, for his pen of five 17 months-old Leicester Shearling Ewes; bred by himself.

William Abraham, of Barnetby-le-Wold, near Brigg, Lincolnshire: the Prize of Fifteen Sovereigns, for his pen of five 16 months-old Leicester Shearling Ewes; bred by himself.

William Sanday, of Holme Pierrepont, near Nottingham: the Prize of Ten Sovereigns, for his pen of five 16 months-old Leicester Shearling Ewes; bred by himself.

SHEEP: II. *Southdowns or other Short-woolled Sheep.*

JONAS WEBB, of Babraham, near Cambridge: the Prize of THIRTY-FIVE SOVEREIGNS, for his 17 months-old Southdown Ram; bred by himself.

JONAS WEBB, of Babraham, near Cambridge: the Prize of TWENTY SOVEREIGNS, for his 16 months-old Southdown Ram; bred by himself.

JONAS WEBB, of Babraham, near Cambridge: the Prize of TEN SOVEREIGNS, for his 16 months-old Southdown Ram; bred by himself.

WILLIAM RIGDEN, of Hove, near Brighton: the Prize of THIRTY SOVEREIGNS, for his 28½ months-old Southdown Ram; bred by himself.

JONAS WEBB, of Babraham, near Cambridge: the Prize of TWENTY SOVEREIGNS, for his 2 years and 5 months-old Southdown Ram; bred by himself.

JONAS WEBB, of Babraham, near Cambridge: the Prize of TEN SOVEREIGNS, for his 3 years and 4 months-old Southdown Ram; bred by himself.

JONAS WEBB, of Babraham, near Cambridge: the Prize of TWENTY SOVEREIGNS, for his pen of five 16 months-old Southdown Shearling Ewes; bred by himself.

JONAS WEBB, of Babraham, near Cambridge: the Prize of FIFTEEN SOVEREIGNS, for his pen of five 16 months-old Southdown Shearling Ewes; bred by himself.

WILLIAM RIGDEN, of Hove, near Brighton: the Prize of TEN SOVEREIGNS, for his pen of five 16½ months old Southdown Shearling Ewes; bred by himself.

SHEEP: III, *Long Wools not Leicesters.*

WILLIAM GARNE, of Aldsworth, near Northleach, Gloucestershire: the Prize of TWENTY-FIVE SOVEREIGNS, for his 16 months-old Cotswold Ram; bred by himself.

WILLIAM LANE, of Eastington, near Northleach, Gloucestershire: the Prize of FIFTEEN SOVEREIGNS, for his 16 months-old Cotswold Ram; bred by himself.

GEORGE HEWER, of Ley Gore, near Northleach, Gloucestershire: the Prize of TWENTY SOVEREIGNS, for his 40 months-old Cotswold Ram; bred by Wm. Hewer, of Northleach, Gloucestershire.

WILLIAM GARNE, of Aldsworth, near Northleach, Gloucestershire: the Prize of TEN SOVEREIGNS, for his 40 months-old Cotswold Ram; bred by himself.

WILLIAM LANE, of Eastington, near Northleach, Gloucestershire: the Prize of TEN SOVEREIGNS, for his pen of five 16 months-old Cotswold Shearling Ewes; bred by himself.

WILLIAM LANE, of Eastington, near Northleach, Gloucestershire: the Prize of FIVE SOVEREIGNS, for his pen of five 16 months-old Cotswold Shearling Ewes; bred by himself.

SHEEP: IV. *Mountain.*

JOHN DODD, of Catcleugh, near Otterburn, Northumberland: the Prize of TWENTY SOVEREIGNS, for his 27 months-old pure Cheviot Ram; bred by himself.

JOHN ROBSON, of East Kielder, near Bellingham, Northumberland: the Prize of TEN SOVEREIGNS, for his 3 years and 4 months-old Cheviot Ram; bred by himself.

JOHN NURCOMBE, of Hopcott Farm, near Minehead, Somersetshire: the Prize of TEN SOVEREIGNS, for his pen of five 16½ months-old pure Exmoor Horn Shearling Ewes; bred by himself.

JOHN ROBSON, of East Kielder, near Bellingham, Northumberland: the Prize of TEN SOVEREIGNS, for his pen of five 2 years and 4 months-old Cheviot Ewes; bred by himself.

PIGS.

R. BRODHURST HILL, of Bache Hall, near Chester: the Prize of FIFTEEN SOVEREIGNS, for his 3 years and 11 months-old Boar, of a large breed; bred by Ashley Henry Wilson, of the Abbey, near Wigton, Cumberland.

GEORGE EDWARD TAYLOR, of Oatlands Mill, near Leeds, Yorkshire: the Prize of TEN SOVEREIGNS, for his 2 years and three months-old Boar, of a large breed; bred by James Martin, of Meanwood, near Leeds, Yorkshire.

JOHN B. SPEARING, of Chilton, near Hungerford, Berks: the Prize of Five SOVEREIGNS, for his 2 years and 6 months-old Improved Berks, Sussex, and Neapolitan Cross Boar, of a large breed; bred by himself.

JAMES DIXON, of Westbrook Place, Horton, near Bradford, Yorkshire: the Prize of FIFTEEN SOVEREIGNS, for his 2 years and 1 month-old Boar, of a small breed; bred by Mr. John Hadwen, of Kebroyd, near Halifax.

WILLIAM LUDLAM, of Bradford, Yorkshire: the Prize of TEN SOVEREIGNS, for his 2 years and 4 months-old Boar, of a small breed; bred by himself.

JOHN RADMORE, of Thorverton, near Cullompton, Devon: the Prize of FIVE SOVEREIGNS, for his 10 months-old Leicester Boar, of a small breed; bred by himself.

JOSEPH TULEY, of Keighley, Yorkshire: the Prize of FIFTEEN SOVEREIGNS, for his 1 year 2 months and 6 days-old Sow, of a large breed; bred by himself.

CHARLES JACKSON, of 46, Goodram Gate, York: the Prize of FIVE SOVEREIGNS, for his 1 year 11 months and 2 weeks-old Sow, of a large breed; bred by himself.

SAMUEL DRUCE, Junr., of Eynsham, near Oxford: the Prize of FIFTEEN SOVEREIGNS, for his 1 year and 2½ months-old Improved Oxfordshire Sow, of a small breed; bred by Thomas Bowerman, of Eynsham.

GEORGE EDWARD TAYLOR, of Oatlands Mill, near Leeds, Yorkshire: the Prize of FIVE SOVEREIGNS, for his 1 year and 2 months-old Sow, of a small breed; bred by himself.

JOSEPH TULEY, of Keighley, Yorkshire: the Prize of TEN SOVEREIGNS, for his pen of three 7 months and 2 weeks-old Breeding Sow Pigs, of a large breed; bred by himself.

MATTHEW NEWMAN, of Court Farm, Hayes, near Uxbridge, Middlesex: the Prize of FIVE SOVEREIGNS, for his pen of three 7 months and 5 days-old Improved Berkshire and Essex Sow Pigs, of a large breed; bred by himself.

E. G. BARNARD, M.P., of Gosfield Hall, near Halstead, Essex (deceased): the Prize of TEN SOVEREIGNS, for his pen of three 22 weeks-old Improved Essex Sow Pigs of a small breed; bred by himself.

E. G. BARNARD, M.P., of Gosfield Hall, near Halstead, Essex (deceased): the Prize of FIVE SOVEREIGNS, for his pen of three 32 weeks-old Improved Essex Sow Pigs, of a small breed; bred by himself.

Commendations.

John Smith Crosland, of Burbage House, near Hinckley: a Short-horned Bull; bred by himself.

Joseph Gillett, of Little Haseley, near Wheatley: a Durham Bull; bred by himself.

James Pearson, of St. Sampson's Square, York: a pure Short-horned Bull; bred by Lord Feversham, of Duncombe Park.

William Raine, of Morton Tinmouth, near Darlington: a pure Short-horned Bull; bred by himself.

Charles Towneley, of Towneley Park, near Burnley: a Short-horned Bull; bred by Richard Eastwood, of Swinshow, near Burnley.

Richard Charles Lowndes, of Rice House, Liverpool: a Short-horned Bull; bred by himself.

Thomas Chrisp, of Hawkhill, Northumberland: a Short-horned Bull: bred by himself.

Thomas S. Atkins, of Kimberley, Norfolk: a Short-horned Durham Bull: breeder unknown.

John Squire Gray, of Morwick Hall, near Leeds: a Short-horned Bull; bred by himself.

James Douglas, of Athelstaneford, New Mains, near Drem, N. B.: a Short-horned Bull; bred by Colonel Cradock, of Hartforth, Yorkshire.

F. H. Fawkes, of Farnley Hall, near Otley, Yorkshire: a Short-horned Bull; bred by himself.

Charles Towneley, of Towneley Park, near Burnley: a Short-horned Bull; bred by himself.

Benjamin Wilson, of Brawith, near Thirsk: a Short-horned Bull; bred by himself.

Sir Charles R. Tempest, Bart., of Broughton Hall, Yorkshire: a Short-horned Bull; bred by Mr. Unthank, of Netherscales, Penrith.

Harvey Combe, of Cobham Park, Surrey: a Short-horned Bull; bred by himself.

Henry Lister Maw, of Tetley, Lincolnshire: a Short-horned in-Calf Heifer; bred by himself.

Richard Stratton, of Salthrop, Wilts: a Short-horned in-Calf Heifer; bred by himself.

Charles Towneley, of Towneley Park, near Burnley: a pure Short-horned in-Calf Heifer; bred by Sir Charles Tempest, Bart., of Broughton Hall, Yorkshire.

William Fletcher, of Radmanthwaite, Nottinghamshire: a Short-horned in-Calf Heifer: bred by himself.

The Hon. Henry Noel Hill, of Berrington, Shrewsbury: a pure Short-horned Heifer; bred by himself.

William Smith, of West Rasen, Lincolnshire: a Short-horned Heifer; bred by himself.

William Smith, of West Rasen, Lincolnshire: a Short-horned Heifer; bred by himself.

John Kirkham, of Hagnaby, Lincolnshire: a pure Short-horned Heifer; bred by himself.

William Smith, of West Rasen, Lincolnshire: a Short-horned Heifer; bred by himself.

Lord Feversham, of Duncombe Park, Yorkshire: a pure Short-horned Heifer; bred by himself.

E. W. Smythe Owen, of Condover Hall, Salop: a Short-horned Heifer; bred by himself.

Benjamin Wilson, of Brawith, Yorkshire: a Short-horned Heifer; bred by himself.

Benjamin Wilson, of Brawith, Yorkshire: a Short-horned Heifer; bred by himself.

John Booth, of Killerby, Yorkshire: a Short-horned Heifer; bred by himself.

Richard Booth, of Warlaby, Yorkshire: a Short-horned Heifer; bred by himself.

James Douglas, of Athelstaneford, near Drem, N.B.: a Short-horned Heifer; bred by himself.

Mark S. Stewart, of Southwick, near Dumfries, N.B.: a Short-horned Heifer; bred by himself.

Thomas Crisp, of Gedgrave, Suffolk: a Short-Horned Heifer; bred by himself.

Rev. J. R. Smythies, of East Hill, Essex: a "true Hereford Bull;" bred by Samuel Aston, of Lynch Court, Leominster.

*James Walker, of North Leach: a Hereford Bull; bred by himself.

Philip Turner, of The Leen, Pembridge: a Hereford Bull; bred by himself.

*Rev. J. R. Smythies, of East Hill, Essex: a Hereford in-milk Cow; bred by Samuel Aston, of Lynch Court, near Leominster.

*John Walker, of Westfield House, Holmer, near Hereford: a Hereford in-Calf Cow; bred by David Williams, of Newton, near Brecon.

*John Monkhouse, of The Stow, near Hereford: a Hereford in-milk and in-Calf Cow; bred by himself.

Rev. J. R. Smythies, of East Hill, Essex: a "true Hereford in-Calf Heifer;" bred by Samuel Aston, of Lynch Court, near Leominster.

*Lord Berwick, of Cronkhill, near Shrewsbury: a Hereford Yearling Heifer; bred by himself.

*Edward Price, of The Court House, Pembridge: a Hereford Yearling Heifer; bred by himself.

*Edward Williams, of Lowess Court, Breconshire: a Hereford Yearling Heifer; bred by himself.

John Addiss, of Clehonger, near Hereford: a Hereford Yearling Heifer; bred by himself.

The Earl of Leicester, of Holkham Hall, Norfolk: a pure North Devon Bull; bred by himself.

*Thomas Miller, of Castle Farm, Dorset: a pure Devon Bull: bred by Mr. Bouchier, of Wiveliscombe.

John A. Thomas, of Rose Ash, Devon: a North Devon Bull; bred by himself.

George Turner, of Barton, near Exeter: a pure North Devon in-Calf and in-milk Cow; bred by himself.

*George Turner, of Barton, near Exeter: a pure North Devon in-Calf Cow; bred by the late Mr. Ley, of Kenn, Devon.

T. W. Fouracre, of Durston, Somerset: a Devon in-milk Cow; bred by himself.

*Samuel Farthing, of Stowey Court, Somerset: a pure Devon in-Calf Heifer; bred by himself.

*Samuel Farthing, of Stowey Court, Somerset: a pure Devon in-Calf Heifer; bred by himself.

*J. K. Farthing, of Nether Stowey, Somerset; a pure Devon in-Calf Heifer; bred by himself.

Samuel Farthing, of Stowey Court, Somerset; a pure Devon Yearling Heifer; bred by himself.

JOHN NURCOMBE, of Hopcott Farm, Somerset: a North Devon Yearling Heifer; bred by himself.

*W. M. GIBBS, of Bishop's Lydeard, Somerset: a Devon Yearling Heifer; bred by himself.

JOHN BOSWELL, of Iver, Bucks: a Channel Islands' Bull; bred by himself.

HENRY LE MESSURIER, of Des Jéhans, Torteval Parish, Guernsey: a pure Channel Islands' Bull; bred by himself.

JOHN HUME, of Beau Regard, Jersey: a Jersey in-milk and in-Calf Cow; bred by Philip A. Huive, of St. Clements, Jersey.

PHILIP DAUNCEY, of Harwood, Bucks: a Channel Islands' in-Calf Cow; bred by himself.

*PHILIP DAUNCEY, of Harwood, Bucks: a Channel Islands' in-Calf Heifer; bred by himself.

*JAMES GORRINGE, of Tilton Farm, Sussex: a Sussex Bull; bred by Thomas and Samuel Pix, of Peasmarsh, Sussex.

*THOMAS CHILD, of Michelham, Sussex: a Sussex in-milk Cow; bred by himself.

WILLIAM FULLERTON, of Ardovie Mains, Forfarshire: an Angus polled Yearling Heifer; bred by himself.

*F. LEYBORNE POPHAM, of Littlecote, Wilts: a pure Cart Stallion; bred by J. Grimstead, Farmer, Nylands, Somerset.

In consequence of a mistake in respect to the Certificate, Mr. Popham's Horse was placed in Class I., instead of in Class II.; and thus was precluded from competing with the Horses of his own age.

*HENRY STEVENS and EDWARD HAYNES, of Hammond's Farm, Middlesex: an Agricultural Mare and Foal; the mare bred by the late Mr. Fowler; the sire of the foal belonged to George Wilson, of Egham, Surrey.

*JONAS WEBB, of Babraham: a Southdown Ram; bred by himself.

*JONAS WEBB, of Babraham: a Southdown Ram; bred by himself.

*JONAS WEBB, of Babraham: a Southdown Ram; bred by himself.

*ROBERT BOYS, of Eastbourne: a Southdown Ram; bred by himself.

*WILLIAM SAINSBURY, of West Lavington, Wilts; a Southdown Ram; bred by the late James Beaven, of Gore Farm, Wilts.

*J. R. OVERMAN, of Burnham Sutton, Norfolk; a Southdown Ram; bred by himself.

*JOHN VILLIERS SHELLEY, of Maresfield Park, Sussex: a pen of 5 pure Southdown Shearling Ewes; bred by himself.

*J. R. OVERMAN, of Burnham Sutton, Norfolk: a pen of 5 Southdown Shearling Ewes; bred by himself.

CHARLES LARGE, of Broadwell, Gloucestershire: a new Oxfordshire Ram; bred by himself.

GEORGE HEWER, of Ley Gore, Gloucestershire: a Cotswold Ram; bred by himself.

*WILLIAM LANE, of Eastington, Gloucestershire: a Cotswold Ram; bred by himself.

CHARLES LARGE, of Broadwell, Gloucestershire: a new Oxfordshire Ram; bred by himself.

WILLIAM GARNE, of Aldsworth, Gloucestershire: a Cotswold Ram; bred by himself.

GEORGE HEWER, of Ley Gore, Gloucestershire: a Cotswold Ram; bred by William Hewer, of Northleach.

*EDWARD BOWLY, of Siddington House, Gloucestershire: an improved Berkshire Boar, of a large breed; bred by himself.

*JOHN HENRY DOWNS, of Gray's Thurrock, Essex: a Yorkshire Boar, of a small breed; bred by R. W. Saunders, of Nunwick Hall, Cumberland.

The EARL of RADNOR, of Coleshill, Berks: a Coleshill Boar, of a small breed; bred by himself.

*JOHN RADMORE, of Thorverton, Devon: a Leicester Boar, of a small breed; bred by himself.

HENRY WATSON, of Londonthorpe, Lincolnshire: an improved Nottinghamshire Boar, of a small breed; bred by himself.

*WILLIAM ABBOTT, of Woodhouse Carr, Yorkshire: a Sow of a large breed; bred by John Midgley, of Meanwood, near Leeds.

JAMES ROBINSON, of Phœnix Mill, Yorkshire: a Sow of a large breed; bred by Abraham Houldsworth, of Moore Bottom, Yorkshire.

JOSEPH TULEY, of Keighley, Yorkshire: a Sow of a large breed; bred by Thomas Pickard, of Exleyhead, Yorkshire.

EDWARD BOWLY, of Siddington House, Gloucestershire: an improved Berkshire Sow, of a large breed; bred by himself.

MOSES CARTWRIGHT, of Stanton Hill, Staffs.: a Tamworth Sow, of a large breed; bred by himself.

JOHN RADMORE, of Thorverton, Devon: a Leicester Sow, of a small breed; bred by himself.

*TIMOTHY TOWN, of Keighley, Yorkshire: a Sow of a small breed; bred by Christopher Saxton, of Morton Banks, Yorkshire.

The EARL of RADNOR, of Coleshill, Berks: a Coleshill Sow, of a small breed; bred by himself.

E. G. BARNARD, M.P., of Gosfield Hall, Essex (deceased): a pen of three improved Essex Sow Pigs, of a small breed; bred by himself.

These Commendations are arranged in the order of the numbers of the Certificates to which they refer. The mark (*) signifies "HIGHLY COMMENDED;" the omission of it, "COMMENDED;" by the Judges.

Royal Agricultural Society of England.

ANNUAL COUNTRY MEETING OF 1852,

TO BE HELD

AT LEWES, IN SUSSEX,

FOR THE SOUTH-EASTERN DISTRICT, COMPRISING THE COUNTIES OF KENT, SURREY, AND SUSSEX.

Prizes for Agricultural Implements and Machinery: with the Conditions for their Competition, and general Regulations for their Exhibition and Trial.

The Prizes are open to general competition; Members of the Society having the privilege of a free entry; while non-Subscribers are allowed to compete on the payment of 5*s.* on each certificate.

Forms of Certificate to be obtained on application to the Secretary, 12, Hanover-square, London. All Certificates for the entry of Implements, &c., will be required to state the total number of articles entered to be shown by each Exhibitor, and the space required for their exhibition; and must be returned, filled up, to the Secretary, on or before the 1st of May, 1852: the Council having decided that in no case whatever shall any such Certificate of Implements be received after that date.

PRIZES.

No. of Prize.		£
1.	For the Plough best adapted for general purposes	7
2.	For the Plough best adapted for Deep Ploughing	7
3.	For the best One-way or Turn-wrest Plough	7
4.	For the best Paring Plough	5
5.	For the best Subsoil Pulverizer	5
6.	For the best Drill for general purposes	10
7.	For the best Steerage Corn and Turnip Drill	10
8.	For the best Drill for small occupations	5
9.	For the best and most economical Small-occupation Seed and Manure Drill for flat or ridged work	5
10.	For the best Turnip Drill on the flat	10
11.	For the best Turnip Drill on the ridge	10
12.	For the best Drop Drill, for depositing seed and manure	10
13.	For the best Manure Distributor	5
14.	For the best Portable Steam-Engine, not exceeding 6-horse power, applicable to Thrashing or other agricultural purposes	40
..	For the second-best ditto, ditto	20

		£
15.	For the best Fixed Steam-Engine, not exceeding 8-horse power, applicable to Thrashing or other agricultural purposes	20
..	For the second-best ditto, ditto	10
16.	For the best Portable Thrashing Machine, not exceeding 2-horse power, for small occupations	10
17.	For the best Portable Thrashing Machine, not exceeding 6-horse power, for larger occupations	20
18.	For the best Portable Thrashing Machine, not exceeding 6-horse power, with shaker and riddle: to be driven by steam	20
19.	For the best Fixed Thrashing Machine, not exceeding 6-horse power, with straw-shaker, riddle, and winnower, that will best prepare the corn for the finishing dressing-machine: to be driven by steam	20
20.	For the best Corn-dressing Machine	10
21.	For the best Grinding-Mill for breaking agricultural produce into fine meal	10
22.	For the best Linseed and Corn-Crusher	5
23.	For the best Chaff-Cutter, to be worked by horse or steam power	10
24.	For the best Chaff-Cutter, to be worked by hand-power	5
25.	For the best Turnip-Cutter	5
26.	For the best Oilcake-Breaker for every variety of cake	5
27.	For the best One-Horse Cart for general purposes	10
28.	For the best Light Waggon for general purposes	10
29.	For the best Machine for making Draining Tiles or Pipes for agricultural purposes	20
30.	For the best Instruments for Hand-use in Drainage	3
31.	For the best Heavy Harrow	5
32.	For the best Light Harrow	5
33.	For the best Cultivator, Grubber, and Scarifier	10
34.	For the best Pair-Horse Scarifier	5
35.	For the best Horse Hoe on the flat	10
36.	For the best Horse Hoe on the ridge	5
37.	For the best Horse Rake	5
38.	For the best Horse Seed-Dibbler or Seed-Depositor, not being a drill	10
39.	For the best Gorse-Bruiser	5
40.	For the best and most economical Steaming Apparatus for general purposes	5
41.	For the best Dynamometer, especially applicable to the traction of ploughs	5
42.	Miscellaneous Awards and Essential Improvements, Fourteen Silver Medals estimated at	21
43.	For the Invention of any New Implement, such sum as the Council may think proper to award	..
44.	For the best Plough to fill in the soil cast out of drains, with not more than 4 horses, two and two abreast (offered by R. A. Slaney, Esq., M.P.)	10

Conditions.

Prize

No. 6.—The *Drill for General Purposes* will be preferred which shall possess the most approved method of distributing compost or other manure, in a moist or dry state—quantity being especially considered. Other qualities being equal, the preference will be given to the drill which may be best adapted to cover the manure with soil before the seed is deposited.

No. 9.—The *Small-occupation Seed and Manure Drill* will not compete with the drill of a higher price, as its cheapness to the purchaser will be a material consideration.

Nos. 10, 11.—The *Turnip Drills on the Flat and Ridge*, respectively, will be preferred which shall possess the most approved method of distributing compost or other manure in a moist or dry state—quantity being especially considered. Other qualities being equal, the preference will be given to the drill which may be best adapted to cover the manure with soil before the seed is deposited.

No. 13.—The *Manure Distributor* will be preferred which is best adapted for distributing broad-cast any kind of compost or hand-tillage, when in a moist or dry state; and which is capable of adjustment for the delivery of any quantity from 2 to 20 bushels per acre.

No. 14.—The *Portable Steam-Engine* must not be more than six-horse nominal power; the diameter of the cylinder not to exceed $8\frac{1}{2}$ inches. The Exhibitor will be required to furnish to the Society, along with the specification, a longitudinal and transverse sectional plan of the boiler, showing the action of the fire upon the flues; and also to state in writing the thickness and quality of the boiler plates, as well as the diameter of the cylinder, the length of stroke of the piston, the number of revolutions of the crank-shaft (with its diameter, and whether made of wrought or cast iron), the diameter and weight of the fly-wheel, the diameter of the driving pulley (which should not be less than $5\frac{1}{2}$ inches wide, nor move at a rate less than 1600 feet per minute), the number of horse-power the engine is calculated to work at, the probable time it will require to generate the steam (taking water at 60°) and raise it up to the working pressure (not to exceed 45 lbs. on the square inch), the quantity of fuel it will consume in getting up the steam, and the consumption of fuel for every hour it is in full work. The engine must be provided with a good water-gauge, and with a short piece of pipe fitted with a cock having a thread to fit the $\frac{3}{4}$-inch gas-pipe, for the purpose of fixing a pressure-gauge. Also a 2-inch cock must be attached to the steam-chest of the boiler, such cock to have the usual gas thread for the purpose of taking steam from the boiler, should the Society require to do so. The Society will be empowered to select any engine for the purpose of driving other machinery under trial, and will pay the Exhibitor 1*l.* a-day for the use of the engine and a competent attendant, during the time the services of such engine may be required.

No. 15.—The *Fixed Steam-Engine* must not be more than 8-horse power, the diameter of the cylinder not to exceed $10\frac{1}{4}$ inches; the Exhibitor will not be required to bring a boiler, as steam will be furnished by boilers supplied by the Society; but he will be required to *fix* the engine, also to find the materials for doing so, at his own expense, and in such a position in the trial-yard as may be pointed out to him. He must also furnish the Society with plans and specifications, describing fully the boiler and fittings that he would supply to his customer with the engine he exhibits. The drawings must show fully the form of the flues, and the mode of setting the boiler; and the specification must describe the quality of the iron

Prize.

and the thickness of the plates in the boiler, the distance and diameter of the rivets, also the leading particulars of the engine he intends to exhibit, such as horse-power of the engine, diameter of the cylinder, length of stroke, number of strokes per minute, diameter of crank-shaft (and whether it is made of wrought or cast iron), diameter and weight of fly-wheel, diameter of driving-pulley, which should not be less than 6 inches wide, nor travel less than 1200 feet per minute. The drawings and specifications relating to the Prize-Engines will remain the copyright-property of the Society. The engine exhibited must be supplied with a governor, and have a starting cock to regulate the supply of steam, and be fitted with a thread equal to the 2-inch gas-pipe.—The Judges will be instructed to employ in the trial of the steam-engines an apparatus known as a Force-Resister, as a test of power, such apparatus consisting of a friction-break, to supply and regulate the friction required to balance the power of the engine, as well as to show the utmost resistance for any quantity of power the engine on trial may require.

No. 29.—With the *Draining Tile or Pipe Machine*, specimens of the tiles or pipes will be required to be shown in the yard; the price at which these have been sold must be stated, and will be taken into consideration; and proof of the working of the machine itself to be given to the satisfaction of the Judges.

Hand and Power Machines.—The Exhibitors of such machines as are usually worked by hand must provide and fix on them pulleys not less than 4 inches wide, such pulleys to be equal in diameter to twice the length of the winch that the machine is usually worked with. The Exhibitors of machines that require to be driven by power must fix on them pulleys of sufficient diameter and width, that they may be easily driven by straps.

Regulations.

Certificates and Specifications.

1. The necessary printed forms of certificates and specifications may be obtained from the Secretary, at No. 12, Hanover Square, London, by persons who are desirous of exhibiting implements, &c.
2. No implements will be admitted for exhibition unless the necessary certificate, filled in on the printed form prescribed, complete, and signed by the exhibitor (or his agent), in the manner directed, has been delivered to the Secretary, or sent (postage free), directed to him, so as to reach No. 12, Hanover Square, on or before the 1st of May, 1852. The specifications and any additional particulars of such implements need not be delivered until the 1st of June, 1852; but if such specifications and necessary particulars, required by the printed rules, should be neglected to be sent by that time, such implement as that informality affects will be disqualified for exhibition. For the satisfaction of Exhibitors, the Secretary will acknowledge by return of post the due receipt and registration of the certificates.
3. The certificate sent in by the 1st of May must state the space each Exhibitor will require (the sheds being 20 feet wide), in order that the Director or Stewards may apportion the standing-room among the various parties who make application. Exhibitors will have to pay 1*s*. per foot run towards defraying the expense of erecting the shedding, which amount must be remitted to the Secretary with the certificate by the 1st of May.

4. Persons who intend to send their own horses and driver to work in the trial-field must declare, in the certificate, their intention of doing so.
5. A description of each article intended to be shown must be written on one side only of the specification: it must state the name and address (when they are known) of the inventor, the improver, and the manufacturer: it must also detail the improvements (if any), peculiarities, &c., of each implement.
6. The specification must state the lowest selling price of each article; and each Exhibitor shall be bound to execute all orders given to him in the show-yard at the price stated in his specification.
7. If an article is intended to compete for the prize offered for "any new agricultural implement," it must be entered as such in the specification.
8. If a prize or medal has been awarded at a previous meeting of the Society to any implement which is entered for exhibition at Lewes, the specification must state whether it was a prize or medal, or both, and the date at which it was awarded; if a prize, the amount must be stated.
9. If any improvement has been made in the implement subsequently to that award, a description and drawing of the improvement must accompany the specification.
10. Exhibitors of implements, in sending-in the specification of their different articles for publication in the Catalogue, must confine themselves to stating such particulars *only* as are required by the regulations of the Prize Sheet, as the insertion of additional particulars must be paid for at the rate of *one shilling a line,* with a view to prevent the *unnecessary* enlargement of the Catalogue.
11. In order to check the entry of implements which are not intended to be exhibited, a fine of 5*s.* on implements under 10*l.* in value, and a fine of 10*s.* on implements of 10*l.* and upwards in value, will be charged on each implement entered and not exhibited, unless a certificate shall be sent to the Secretary, on or before the day of exhibition, that the non-exhibition is caused by unavoidable accident.

Arrival of Implements, &c.

12. All implements, &c., entered for exhibition, must be brought to the show-yard before five o'clock in the evening of the Thursday preceding the week of exhibition.
13. No implement, &c., will be admitted into the yard for exhibition unless it has been described as a separate article, in the form prepared for that purpose, delivered to the Secretary as above.
14. A ticket, bearing the number corresponding with the specification, must be attached to some conspicuous part of each implement before it is brought to the gate.
15. The admission order, which will be sent for articles properly entered, must be delivered to the gate-keeper of the yard by the person who brings the articles for admission.
16. No implement having upon it paint or varnish that is wet will be allowed to enter the yard.

Arrangement of Implements.

17. All implements must be unpacked and arranged in each stand, by the exhibitor, according to their numbers, and in the same direction as the numbers of the different stands run, consecutively. Exhibitors are requested to have them arranged by five o'clock in the evening of Thursday in the week preceding that of exhibition, as the Judges will commence their inspection early on the following morning. All implements, &c., that are not unpacked by that hour will be removed from the yard.
18. No implement will be allowed to be painted or varnished after it has entered the yard.

Trial.

19. All implements admitted to the exhibition will be liable, upon the recommendation of the Judges, to have their capabilities proved by actual trial.
20. (1) All implements turned by the winch or hand-crank shall not be worked at any trial beyond the following speed; namely, 40 revolutions per minute for 12-inch crank, 35 revolutions for 14-inch crank, 30 revolutions for 16-inch crank. (2) In machinery driven by horse-power, the utmost speed that the horses shall be driven at during any trial shall not exceed $2\frac{1}{4}$ miles per hour, or 198 feet per minute. (3) Steam-machinery shall, under no circumstances, be allowed to compete at any trial with a greater pressure than 45 lbs. per square inch in the boiler; at which pressure it will be expected that the engine shall work up to the power declared by the exhibitor.—*The quantity of fuel consumed by each engine will be strictly ascertained by the Judges.*
21. Ample private trial will be given to such implements as the Judges shall select, and at such time and place as the Stewards may appoint.
22. No person will be permitted to remove any implement from the yard to the trial-field, unless by the express orders of the Director or Stewards, upon the recommendation of the Judges.
23. Exhibitors are requested to be in attendance during the trials of their own implements, and in the implement-yard while the Judges are inspecting the implements, in case any explanation may be required from them.
24. No implement will be allowed to commence work in the trial-field, unless by the express orders of the Judges or Stewards.
25. Notice of the nature of the soil upon which the trials are to take place will, if necessary, be given to the exhibitors by the Secretary.
26. Chaff-cutters, corn-crushers, and other small implements, will be removed, for trial, into the space attached to the implement-yard (called the "trial-yard"), into which space the Judges of implements, and the exhibitor during the trial of his implement, will alone be admitted.
27. Hay, straw, turnips, &c., may be brought with the implements for the purpose of being used in the trial of those implements.

Consulting Engineer.

28. The Consulting Engineer will be in attendance in the yard, and during the trials, to examine the implements.
29. The Consulting Engineer will not act as one of the Judges of implements, but only as mechanical referee whenever the Stewards and Judges may deem it necessary to call in his aid.

Departure of Implements, &c. (*after the Show*).

30. No implements, excepting those selected for trial, can be removed from the yard until 6 o'clock on the evening of Thursday in the week of exhibition.
31. The "Delivery Order," filled up and signed by the exhibitor or his agent, must be delivered to the gate-keeper; no implement can be removed without it.

General and Miscellaneous Regulations.

32. Non-Subscribers wishing to exhibit implements, &c., are required to pay 5*s.* as an entrance-fee. This payment must be sent by a Post-office Order, made payable to the Secretary, and enclosed with the certificate by the 1st of May: a neglect in making such remittance may invalidate their entry.
33. Implements which have been removed to the trial-field must be brought back to the yard, and replaced according to their numbers, either on Tuesday evening, or Wednesday morning before 6 o'clock, in the week of show.
34. No fire will be allowed to be lighted in the show-yard for any steam-engine or other implement.

35. After the Report on the Trial and Exhibition of the Implements has appeared in the Journal, a copy of that Report will be delivered gratis to such exhibitors of implements as may not be members of the Society, upon their making application for it to the Secretary, at No. 12, Hanover Square.
36. Exhibitors of implements will have a free ticket of admission sent to them, along with their "Admission Order."
37. The Judges' decision will in all cases be final.
38. If a notice in writing shall be delivered to the Stewards that any invention is considered to be an infringement of the right of another party, the implement may still be tried if selected by the Judges for that purpose; and if on such trial the invention should be found to merit the prize, the prize shall be awarded, subject to the condition of payment being suspended for a reasonable period, to allow the trial of the rights of the parties at law; and if no steps at law are taken in the next term, the award shall be absolute.
39. Any person who shall have been shown, to the satisfaction of the Council, to have been excluded from exhibiting for prizes at the exhibition of any society, in consequence of having been convicted of an attempt to obtain a prize by giving a false certificate, will not be allowed to compete for any of the prizes offered by the Royal Agricultural Society of England, or at any of their Meetings.

Instructions to the Judges.

1. The Judges will have the Friday, Saturday, Monday, and Tuesday, for making their adjudication and signing their awards.

2. The Judges will be instructed neither to divide nor to increase any of the specific prizes. If they should not award any specific prize mentioned in the Prize Sheet, they will be instructed not to appropriate that sum to any other description of implement.

3. If, in the opinion of the Judges, there should be equality of merit, they will be instructed to make a special report to the Council, who will decide on the award.

4. The Judges will be instructed to withhold any prize, if they shall be of opinion that there is not sufficient merit in any of the implements exhibited for such prize to justify an award.

5. The Judges will be requested to observe that, in addition to the specific prizes, there are Ten of the Silver Medals which they have the power of distributing in awards among the Exhibitors of such miscellaneous articles as they may decide to possess sufficient merit.

6. The Judges will also be empowered to award a Silver Medal for any new principle of construction which they may consider an essential improvement, even though the implement in which it is introduced should not be adjudged to be the best of its class. In all such cases it will be necessary for the Judges to specify clearly the exact nature of the improvement for which the Medal is awarded.

7. The Judges will be instructed to deliver to the Director their *final* and *complete* awards of all prizes and medals, *before they leave the yard*, on the evening of Tuesday in the week of exhibition, in order that the necessary placards may be placed on the Prize Implements.

8. The Judges will be requested to observe that it is left to their discretion to select the implements for trial.

9. In making their decision, the Judges will be instructed to take the selling prices of the implements into consideration.

10. The Judges will be instructed to pay particular attention to the 20th General Regulation above written.

11. The Judges will be instructed to employ in the trial of the steam-engines an apparatus known as a "Force-Resister," as a test of power—such apparatus consisting of a friction-break, to supply and regulate the friction required to balance the power of the engine, as well as to show the utmost resistance for any quantity of power the engine on trial may require.

12. The Judges will be instructed to ascertain, in every engine, and report in their award, whether regulators or governors are used in the steam-engines which

they recommend for prizes; and also to ascertain the temperature of the water in the boilers immediately prior to the lighting of the fires at the commencement of the trial of the steam-engines.

13. In addition to the Consulting-Engineer of the Society, who acts as mechanical referee, two engineers will be appointed, who will be sole Judges of steam-engines, and of steam-power generally, considered in a scientific and mechanical point of view, without reference to the application of such power to agricultural machinery; and they will be instructed to report to the Stewards in writing, for the information of the other Judges, a statement of the power applied to the machinery under the consideration of any such Judges.

14. The other Judges will judge the work done by any agricultural machine to which steam or other power is applied; but they will be instructed to pay every attention to the report of the engineers in forming their judgment of the work of the machinery on which they are called to adjudicate.

15. The Judges will be instructed, that, in the trial of machines, in every case where practicable, steam-power should be adopted instead of horses, as the most accurate test of the relative working of machinery.

Instructions to the Stewards.

1. The Director and Stewards of the Implement-yard are instructed to take care that no Governor or Member of the Society, Member of Council, or stranger, be admitted into the Implement-yard before the opening of the Exhibition. They are also instructed not to admit into the Trial-yard, adjoining the yard, any person, excepting the Judges, and the Exhibitors during the trial of their respective implements.

2. The Stewards are empowered to make such regulations for the trial of implements as they may consider requisite; and, previously to the time of the Meeting, to place the land which they may select under such culture and management as may ensure a fair and perfect trial.

3. The Stewards will be requested to pay particular attention to the 20th General Regulation above written.

4. The Director and Stewards of the Yard are requested to report the names of the parties who have not exhibited any of the implements entered by them, or who neglect to pay the fines.

5. All Exhibitors' servants in charge of implements will be subject to the orders of the Director and Stewards.

6. The Council also delegates full power to the Director and Stewards to enforce all the above Regulations.

*** *All Exhibitors and persons admitted into the Show-yard shall be subject to the Rules, Orders, and Regulations of the Council.*

*** As the Prize Sheets of the Society are finally settled each year by the Council, at a date prescribed by the Bye-Laws, no alteration in the amount and condition of the Prizes offered by the Society for any particular year can be made after such established date. Cheques for the amount of prizes awarded at the Country Meetings of the Society are drawn at the first Monthly Meeting of the Council held in London in the ensuing month of August, and when duly signed are forwarded by post to the respective parties.

By Order of the Council,

JAMES HUDSON, *Secretary.*

London, Aug. 6, 1851.

Essays and Reports.

PRIZES FOR 1852 AND 1854.

All Prizes of the Royal Agricultural Society of England are open to general competition.

*** *Competitors will be expected to consider and discuss the heads enumerated.*

I.—PRIZES FOR 1852.

I. Farming of Cumberland.

Fifty Sovereigns will be given for the best Report on the Farming of the county of Cumberland.

1. Description of strata and soils of the county.
2. Peculiarities of climate as they affect crops.
3. Effect of elevation on the farming of the county.
4. Description of the ancient and of the improved system of farming.
5. Extent to which draining has been practised and is still required.
6. Whether hill-side irrigation has been tried, and to what extent it would be applicable?
7. Improvements made since the Report of J. Bailey and G. Culley in 1805, and to what extent still required?

II. Farming of Herefordshire.

Fifty Sovereigns will be given for the best Report on the Farming of Herefordshire.

1. The character of the soils and subsoils of the county.
2. The use of lime as manure, to what soils (if any) it is confined, and whether its employment is at all diminished by high farming.
3. Manufacture of perry.
4. Effect of soil on the growth of timber-trees.

5. The suitableness or otherwise of the farm buildings to improved husbandry.
6. The extent of under-draining effected in the county.
7. Improvements made since the Report of J. Duncombe in 1805, and to what extent still required.

III. Manufacture of Beet-Root Sugar.

Thirty Sovereigns will be given for the best account of the Manufacture of Sugar from Beet-Root.

1. The cultivation of the root for this purpose in France, Belgium, or Germany, and the extent to which high manuring affects its saccharine contents.
2. Whether mangold-wurzel is applicable to the manufacture of sugar?
3. Manufacture of sugar according to the latest improved processes.
4. Disposal of the refuse for the distillation of spirits, extraction of salts, or feeding of cattle.
5. Comparison of profit per acre from production of sugar or corn at present prices.

IV. Seeds.

Twenty Sovereigns will be given for the best Essay on the Management of the Clovers, Rye-grass, &c., with the best remedy for clover-sickness.

V. Underwood.

Twenty Sovereigns will be given for the best account of the Cultivation and Management of Underwood, founded upon actual experience.

1. The nature of the soil; and when it has been recently planted, the mode of preparing it.
2. The average number of plants per acre.
3. The description of underwood growing.
4. The best sorts to be planted.
5. The cost of fencing and draining.
6. The comparative produce of not less than 5 acres under the common, and under an improved system of management.

VI. Hereditary Diseases and Defects.

Twenty Sovereigns will be given for the best account of those Diseases in the Horse and the Ox which either are or may become hereditary.—As the Sheep and the Pig may probably form the subject of a subsequent prize, competitors are requested to confine themselves in this Essay expressly to the Horse and the Ox.

VII. Any other Agricultural Subject.

Twenty Sovereigns will be given for the best Essay on any other Agricultural subject.

VIII. Steam and other Motive Power.

Thirty Sovereigns will be given for the best Essay on the relative advantages of Steam and other Motive Power applicable to Agricultural purposes.

1. The best mode of applying horse-power.
2. The best mode of applying water-power.
3. The best mode of applying fixed steam-power.
4. The best mode of applying moveable steam-power.
5. Purposes to which power is applicable, as thrashing, chaff-cutting, &c.

The Essays must be sent to the Secretary, at 12, *Hanover Square, London, on or before March* 1, 1852.

II.—PRIZE FOR 1854.

Guano.

Fifty Sovereigns will be given for the best account of the Geographical Distribution of Guano; with suggestions for the discovery of any new source of supply, accompanied by specimens.

The Essays competing for this Prize to be sent in on or before March 1, 1854.

*** Contributors of Papers are requested to retain Copies of their Communications, as the Society cannot be responsible for their return.

RULES OF COMPETITION FOR PRIZE ESSAYS.

1. All information contained in Prize Essays shall be founded on experience or observation, and not on simple reference to books or other sources.

2. Drawings, specimens, or models, drawn or constructed to a stated scale, shall accompany writings requiring them.

3. All competitors shall enclose their names and addresses in a sealed cover, on which only their motto, and the subject of their Essay, and the number of that subject in the Prize List of the Society, shall be written.*

4. The President or Chairman of the Council for the time being shall open the cover on which the motto designating the Essay to which the Prize has been awarded is written, and shall declare the name of the author.

5. The Chairman of the Journal Committee shall alone be empowered to open the motto-paper of such Essays, not obtaining the Prize, as he may think likely to be useful for the Society's objects, with a view of consulting the writer confidentially as to his willingness to place such paper at the disposal of the Journal Committee.

6. The copyright of all Essays gaining prizes shall belong to the Society, who shall accordingly have the power to publish the whole or any part of such Essays; and the other Essays will be returned on the application of the writers; but the Society do not make themselves responsible for their loss.

7. The Society are not bound to award a prize unless they consider one of the Essays deserving of it.

8. In all reports of experiments the expenses shall be accurately detailed.

9. The imperial weights and measures only are those by which calculations are to be made.

10. No prize shall be given for any Essay which has been already in print.

11. Prizes may be taken in money or plate, at the option of the successful candidate.

12. All Essays must be addressed to the Secretary, at the house of the Society.

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* Competitors are requested to write their motto on the paper on which their names are written, as well as on the envelope.

Royal Agricultural Society of England.

1851—1852.

President.

THE EARL OF DUCIE.

Trustees.

Acland, Sir Thomas Dyke, Bart., M.P.
Braybrooke, Lord
Challoner, Colonel
Clive, Hon. Robert Henry, M.P.
Graham, Rt. Hon. Sir Jas., Bart., M.P.
Neeld, Joseph, M.P.
Portman, Lord
Pusey, Philip, M.P.
Richmond, Duke of
Rutland, Duke of
Spencer, Earl
Sutherland, Duke of

Vice-Presidents.

Barker, Thomas Raymond
Chichester, Earl of
Downshire, Marquis of
Ducie, Earl of
Egmont, Earl of
Exeter, Marquis of
Fitzwilliam, Earl
Hardwicke, Earl of
Hill, Viscount
Wellington, Duke of
Yarborough, Earl of

Other Members of Council.

Ashburton, Lord
Austen, Colonel
Barnett, Charles
Beasley, John
Bennett, Samuel
Berners, Lord
Blanshard, Henry
Bramston, Thomas William, M.P.
Brandreth, Humphrey
Burke, John French
Camoys, Lord
Cavendish, William George, M.P.
Childers, John Walbanke, M.P.
Denison, John Evelyn, M.P.
Druce, Samuel
Foley, John Hodgetts H., M.P.
Garrett, Richard
Gibbs, B. T. Brandreth
Grantham, Stephen
Hamond, Anthony
Hobbs, William Fisher
Hodges, Thomas Law, M.P.
Hornsby, Richard
Hudson, John
Johnstone, Sir John V. B., Bart., M.P.
Jonas, Samuel
Kinder, John
Lawes, John Bennet
Lemon, Sir Charles, Bart., M.P.
Miles, William, M.P.
Milward, Richard
Pendarves, E. W. Wynne, M.P.
Price, Sir Robert, Bart., M.P.
Ridley, Sir Matthew White, Bart.
Sewell, Professor
Shaw, William
Shaw, William, junior
Shelley, John Villiers
Sheridan, Richard Brinsley, M.P.
Sillifant, John
Simpson, William
Slaney, Robert Aglionby, M.P.
Smith, Robert
Southampton, Lord
Stansfield, W. R. Crompton, M.P.
Thompson, Henry Stephen
Turner, Charles Hampden
Turner, George
Webb, Jonas
Wilson, Henry

Secretary.

JAMES HUDSON, 12, *Hanover Square, London.*

Consulting-Chemist—JOHN THOMAS WAY, 23, Holles Street, Cavendish Square.
Veterinary-Inspector—JAMES BEART SIMONDS, Royal Veterinary College.
Consulting-Engineer—JAMES EASTON, or C. E. AMOS, The Grove, Southwark.
Seedsmen—THOMAS GIBBS and Co., Corner of Halfmoon Street, Piccadilly.
Publisher—JOHN MURRAY, 50, Albemarle Street.
Bankers—H., A. M., C., A. R., G., and H. DRUMMOND, Charing Cross.

Royal Agricultural Society of England.

GENERAL MEETING,

12, Hanover Square, Saturday, December 13, 1851.

REPORT OF THE COUNCIL.

The Council have to report that, since the last General Meeting, 132 Members have been elected, 69 have died, and 149 have been removed from the list: so that the Society consists accordingly of—

91 Life Governors,
158 Annual Governors,
690 Life Members,
4076 Annual Members, and
19 Honorary Members:

making a total of 5034 Members on the list of the Society at the present time. The Council have filled up the vacancy in their body occasioned by the loss of the Hon. Capt. Pelham, by the election of Mr. Law Hodges, M.P. for West Kent.

The finances of the Society are in a highly favourable state: the floating cash-balance in the hands of the bankers being equal to the discharge of current claims; while the Council have been enabled to purchase Stock in Government Securities to the amount of 11,190*l.*, on account of the investment of life-compositions of Governors and Members, made in accordance with the principle originally laid down as essential to the security of the Society.

The Windsor Meeting has been held, under most gratifying circumstances, and with perfect success. The Members were honoured on the occasion by the gracious presence of her Majesty

the Queen, the Royal Patroness of the Society; and his Royal Highness Prince Albert, as one of its Governors, evinced a lively participation in the proceedings of the Meeting, and with kind condescension sat down to dinner, in the Pavilion, with 2000 guests of the Society, whom he most heartily bid welcome to the Home Park. The Mayor and Corporation and the Local Committee, with the most zealous co-operation, anticipated and executed the wishes of the Council on every point connected with the convenience and accommodation of the Society, and the perfect preservation of the peace of the borough. The railway arrangements were in every respect as complete as the increased pressure of traffic and the multiplicity of details would allow; and the Stock of the Exhibitors was liberally conveyed free of charge, in both directions, by the principal railway companies throughout the kingdom. The number of the stock, the variety of the breeds, and the high character so great a proportion of the animals exhibited, rendered the Show at Windsor one of the most remarkable, perhaps, that has ever taken place in this or any other country: and, notwithstanding the increased expenses attending so large an exhibition, the balance-sheet of the Meeting will be found to present a result more favourable to the Society than on any former occasion.

The Council have arranged that the Lewes Meeting shall be held in the week commencing Monday, the 12th of July next. They have also decided on the Prizes to be offered at that meeting, for Agricultural Implements and Machinery, and for Live Stock intended for breeding purposes. The former include important additions, intended to draw the attention of Agricultural Engineers and Machinists more strongly to the different degrees of motive power required by farmers under different circumstances, and to its convenient adaptation to agricultural purposes: and it is hoped that an opportunity will be afforded for obtaining a satisfactory trial of the efficiency of those reaping machines which have attracted so much attention subsequently to the period when the Prize Sheet for Implements was arranged

by the Council for the year 1852. The latter comprise distinct classes of prizes for the Sussex breed of Cattle, the Romney Marsh or Kentish Sheep, and Domestic Poultry; having reference respectively to the counties of Sussex, Kent, and Surrey, constituting the district of the Country Meeting to be held next year at Lewes. They have made the rule more stringent by which fines are levied on exhibitors for not sending to the show the stock they have entered, and for which the Society provide accommodation in the show-yard. They have resolved that no prize of the Society shall be given to bulls exceeding five years old; they have limited the competition in the class of agricultural stallions hitherto known as that of any age, to horses that are above two years old; and they have decided to require in the class of three years' old heifers not in milk the same certificate as in the case of incalf-cows not in milk, before paying the amount of the prize, namely, a certificate that such incalf-heifer had in due course produced a live calf. The Council have under their anxious consideration two most important questions connected with their Country Meeting: namely, the best mode of appointing the Judges, and the conditions under which their attention should be directed to a veterinary inspection of the animals. The Council consider that the stock to which the prizes of the Society are awarded ought not only in the opinion of the Judges to be the best specimens of their particular class in the yard, but that in condition and function they ought also to be fully qualified to propagate their species, without communicating to their offspring any tendency to hereditary disease or imperfection; and, in order more clearly to call attention to the circumstances under which such tendency might be apprehended, the Council have offered a prize of 20*l.* for the best Essay on the subject. The Council have received from Colonel Le Couteur the scale of points for Jersey cattle which has been found so satisfactory in enabling the Judges of the Royal Agricultural Society in that island to arrive at uniform decisions. At his request these points were placed by the Council in the hands of

the Judges of Channel Islands' cattle at Windsor; and the award of the first prize in that class, although made to an animal bred in the county of Sussex, as well as the other awards, have, it is believed, given entire satisfaction to the Channel Islands' breeders. This scale of points, and the accompanying illustrations, having been placed at the disposal of the Society for publication, in the hope that an equally successful attempt may be made for other breeds of cattle in England, the Journal Committee have directed their insertion in the ensuing number of the Journal. The Council have given directions for the preparation of a plan of the show-yard at Lewes, and have decided that a pavilion for the great dinner shall be constructed to accommodate 1000 persons. At their request, Professor Simonds has kindly consented to deliver a lecture in the week of the Lewes Meeting, on such practical and important questions connected with the management and diseases of animals on a farm, as may be considered most interesting for the purpose. The position of Lewes in reference to the Southdown district, its immediate vicinity to Brighton, its connexion by a navigable river with the sea, and its direct railway communication with London and the West of England, will no doubt render it a place of convenient access both to the breeders of Sussex, the members and exhibitors of the Society, and the public generally, who intend to be present at the meeting; while the great facilities offered by the authorities of the borough, and the immediate residence of so many active members of the Society, will secure the most advantageous arrangements for the occasion.

The Duke of Richmond has reported to the Council the progress of the communications he was requested by them to enter into with Viscount Palmerston, Her Majesty's Principal Secretary of State for the Foreign Department, on the subject of a cheap and abundant supply of guano to this country. His Lordship has signified his entire willingness to lend every aid in furtherance of this important object, by requesting the Admiralty to instruct the commander of every ship in Her Majesty's Navy to search for deposits of guano in the rainless regions within the

tropics, and every surgeon of such ships to be prepared to examine on the spot the amount and quality of each deposit of guano that may be discovered: the search for mineral phosphate of lime in any part of the world being also included in this instruction. Lord Palmerston having also stated his desire that the Council should draw up a code of such instructions and queries they would wish to have distributed by the Admiralty, they have requested the Chemical Committee of the Society to prepare these instructions and queries accordingly. The announcement of this most gratifying participation of Her Majesty's Government in a question affecting in so high a degree the cause of practical agriculture will be received with satisfaction by the Society; and these measures of the Government, with the Prize of 50*l.* already offered by the Society for a statement of the geographical distribution and the discovery of new sources of guano, will, it is hoped, lead to interesting details and important results. In the mean time, as the large proportion of ammonia resulting from guano constitutes, in a great measure, its essential value, it will be an important object to discover a mode by which a cheap and abundant supply of that valuable element may be obtained. The simple and effectual modes now available for detecting adulteration in the guano of commerce ought to prevent the great loss and disappointment to which farmers at the present time are very liable; and in furtherance of this object, Professor Way has reduced his charge for an analysis of this manure to a rate which brings it within the means of every farmer who will take the trouble to guard himself by this analysis from fraud.

The Journals of the Society contain from time to time the results of Professor Way's Chemical Investigations, instituted under the instructions of the Chemical Committee of the Society; and the Lectures which he has delivered to the Members since the last General Meeting, on the agricultural employment of lime and gypsum, have been valuable in themselves, and have led to interesting practical discussions.

The Council have taken means to bring before the Members various suggestions made during the past year for extending in

this country the growth of Flax as an agricultural crop. The conditions of soil and culture, the management of fibre, and the question of there being or not a sure market for its sale, are practical and prudential considerations, which will no doubt of themselves engage the attention of farmers, without any special caution being given to them by the Council; who, although well aware that there are, under ordinary circumstances, no difficulties attending the cultivation of this crop, yet feel at the same time that at present adequate means are not generally available for taking the crop off the grower's hands.

The Council, in conclusion, have the continued satisfaction of calling the attention of the Members to the gradual and vigorous development of the Society in its practical and useful objects, and to the addition of new members to its list from among the friends of agricultural improvement in every part of the United Kingdom.

By order of the Council,

(Signed) JAMES HUDSON,
Secretary.

MEMORANDA.

GENERAL MEETING in London on Saturday the 22nd of May, 1852.

COUNTRY MEETING at Lewes, in Sussex, in the week commencing the 12th of July, 1852.

GENERAL MEETING in London, on the Saturday in the week of the Smithfield Club Show, in December, 1852.

MONTHLY COUNCIL (for legislative business), at 12 o'clock on the first Wednesday in every month, excepting Sept., Oct., and Nov.: open only to Members of Council and Governors.

WEEKLY COUNCIL (for practical communications), at 12 o'clock on all Wednesdays in Feb., March, April, May, June, and July, excepting the first Wednesday in each of those months: open to all Members of the Society.

ADJOURNMENTS.—The Council adjourn over Passion, Easter, and Whitsun weeks; from the first Wednesday in August to that in November; and from the second Wednesday in December to the first Wednesday in February.

GUANO analysed for Members by Prof. WAY (at 23, Holles Street, Cavendish Square, London), at 5*s.* for a partial analysis, and at 10*s.* for a complete analysis.

DISEASES of Cattle, Sheep, and Pigs.—Members have the privilege of applying to the Veterinary Committee of the Society, and of sending animals to the Royal Veterinary College, on the same terms as if they were subscribers to the College (Journal, vol. XI., Appendix, pp. viii, ix; vol. XII., Appendix, p. iv.).

PRIZES for Essays and Reports, 1852 and 1854: terms and conditions given in last Part of Journal (Appendix, pp. xxxi–iv). Essays to be sent to the Secretary by the 1st of March in each year.

PRIZES for Implements, 1852: terms, conditions, and general regulations given in last Journal (Appendix, pp. xxiii–xxx).

CERTIFICATES for Implements to be sent to the Secretary by the 1st of May, 1852.

CERTIFICATES for Live-Stock to be sent to the Secretary by the 1st of June, 1852.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

Half-yearly Account, ending the 30th of June, 1851.

Receipts.

Receipts	£.	s.	d.
Balance in the hands of the Bankers, 1st January, 1851	738	2	8
Balance in the hands of the Secretary, 1st January, 1851	11	9	1
Dividends on Stock	160	6	1
Life-Compositions of Governors	90	0	0
Life-Compositions of Members	360	0	0
Annual Subscriptions of Governors	625	0	0
Annual Subscriptions of Members	3002	7	0
Receipts on account of Journal	266	19	6
Windsor Subscription to Country Meeting of 1851	600	0	0
	£5854	4	4

Payments.

Payments	£.	s.	d.
Permanent Charges	170	12	6
Taxes and Rates	18	2	2
Establishment	481	11	0
Postage and Carriage	28	0	11
Advertisements	3	19	0
Payments on account of Journal	1759	18	3
Chemical Grant: two quarters	100	0	0
Chemical Investigations	200	0	0
Payments on account of Country Meetings	493	0	2
Repayments to Bankers	11	0	0
Sundry Items of Petty Cash	3	9	9
Balance in the hands of the Bankers, 30th June, 1851	2584	9	5
Balance in the hands of the Secretary, 30th June, 1851	0	1	2
	£5854	4	4

(Signed) THOMAS RAYMOND BARKER, *Chairman*,
C. B. CHALLONER,
THOMAS AUSTEN,
HENRY BLANSHARD,
} *Finance Committee.*

Examined, audited, and found correct, this 12th day of December, 1851.

(Signed) THOMAS KNIGHT,
GEO. I. RAYMOND BARKER,
} *Auditors on the part of the Society.*

Royal Agricultural Society of England.

PRIZES

FOR

ESSAYS AND REPORTS.

All Prizes of the Royal Agricultural Society of England are open to General Competition.

		£
1852	Farming of Cumberland	50
	Farming of Herefordshire	50
	Manufacture of Sugar from Beet-root	30
	Management of the Clovers, Rye-grass, &c., and Remedy for Clover-sickness	20
	Cultivation and Management of Underwood	20
	Hereditary Diseases and Defects in the Horse and Ox	20
	Any other Agricultural Subject	20
	Relative Advantages of Steam and other Motive Power applicable to Agricultural purposes	30
1854	Geographical Distribution of Guano; with Suggestions for the Discovery of any New Source of Supply, accompanied by Specimens	50

The Essays and Reports competing for these Prizes are to be sent to the Secretary of the Society, at 12, Hanover-square, on or before the 1st of March, 1852; with the exception of those on Guano, which need not be sent until the 1st of March, 1854. The full particulars and conditions connected with these Essays and Reports have already been given in the Appendix to the last Number of the Journal (page xxxi.). Copies of the prize sheet, containing such particulars and conditions, may be had on application to the Secretary.

AGRICULTURAL IMPLEMENTS AND MACHINERY.

		£
PREPARATION OF LAND.	Plough best adapted for general purposes	7
	Plough best adapted for Deep Ploughing	7
	One-way or Turn-wrest Plough	7
	Paring Plough	5
	Subsoil Pulverizer	5
	Heavy Harrow	5
	Light Harrow	5
	Cultivator, Grubber, and Scarifier	10
	Pair-horse Scarifier	5
CULTIVATION OF CROPS.	Drill for general purposes	10
	Steerage Corn and Turnip Drill	10
	Drill for Small Occupations	5
	Most economical Small-occupation Seed and Manure Drill for Flat or Ridged work	5
	Turnip Drill on the Flat	10
	Turnip Drill on the Ridge	10
	Drop Drill, for depositing Seed and Manure	10
	Manure Distributor	5
	Horse Hoe on the Flat	10
	Horse Hoe on the Ridge	5
	Horse Seed-Dibbler or Seed-Depositor, not being a Drill	10
HARVESTING OF CROPS	One-horse Cart for general purposes	10
	Light Waggon for general purposes	10
	Horse Rake	5
PREPARATION FOR MARKET.	Portable Steam-Engine, not exceeding 6-horse power, applicable to Thrashing or other agricultural purposes	40
	Second-best ditto, ditto	20
	Fixed Steam-Engine, not exceeding 8-horse power, applicable to Thrashing or other agricultural purposes	20
	Second-best ditto, ditto	10
	Portable Thrashing Machine, not exceeding 2-horse power, for Small Occupations	10
	Portable Thrashing Machine, not exceeding 6-horse power, for larger occupations	20
	Portable Thrashing Machine, not exceeding 6-horse power, with shaker and riddle: to be driven by steam	20
	Fixed Thrashing Machine, not exceeding 6-horse power, with straw-shaker, riddle, and winnower, that will best prepare the corn for the finishing dressing-machine: to be driven by steam	20
	Corn-dressing Machine	10
PREPARATION OF FOOD FOR STOCK	Grinding-Mill for breaking agricultural produce into fine meal	10
	Linseed and Corn Crusher	5
	Chaff-Cutter, to be worked by horse or steam power	10
	Chaff-Cutter, to be worked by hand-power	5
	Turnip-Cutter	5
	Oilcake-Breaker for every variety of cake	5
	Gorse-Bruiser	5
	Most economical Steaming-Apparatus for general purposes	5
DRAINING.	Machine for making Draining Tiles or Pipes for agricultural purposes	20
	Instruments for Hand-use in Drainage	3
	Plough to fill in the soil cast out of drains, with not more than 4 horses, two and two abreast (offered by R. A. Slaney, Esq., M.P.)	10
MISCELLANEOUS.	Dynamometer, especially applicable to the traction of ploughs	5
	Miscellaneous Awards and Essential Improvements, Fourteen Silver Medals, estimated at	21
	Invention of any New Implement, such sum as the Council may think proper to award	—

The full particulars and conditions connected with these Prizes were given in the Appendix to the last Number of the Journal (page xxiii.), and the Prize Sheet may be had on application to the Secretary. All Certificates for the Exhibition and Trial of Implements at the Lewes Meeting of the Society to be sent to the Secretary by the 1st of May, 1852.

Royal Agricultural Society of England.

ANNUAL COUNTRY MEETING OF 1852,

FOR THE SOUTH-EASTERN DISTRICT, COMPRISING THE COUNTIES OF KENT, SURREY, AND SUSSEX,

TO BE HELD

AT LEWES, IN SUSSEX,

IN THE WEEK COMMENCING MONDAY THE 12TH OF JULY.

Members have the privilege of a free entry; and non-subscribers are allowed to compete on the payment of 10*s.* on each certificate.

Forms of Certificate to be obtained on application to the Secretary, 12, Hanover-square, London. All certificates for the entry of Implements, and the space required for their exhibition in the show-yard, must be returned, filled up, to the Secretary on or before the 1st of May, and all other certificates by the 1st of June; the Council having decided that in no case whatever shall any entry be received after those dates respectively.

In the application for certificates, the character and age of the animals to be exhibited must be stated; and in order that the proper forms of certificate may be sent, it is requested that in each case the number of the certificate-form corresponding to the prize to be competed for may also be stated.

Prizes for Improving the Breeds of Agricultural Live-Stock:

OPEN TO GENERAL COMPETITION.

I.—CATTLE.

Number of Certificate Form.	Class.	1.—SHORT-HORNS.	£.
1.	1.	To the owner of the best Bull, not exceeding five years old, calved previously to the 1st of January, 1850 .	40
		To the owner of the second-best ditto ditto . .	20
2.	2.	To the owner of the best Bull calved since the 1st of January, 1850, and more than one year old . . .	25
		To the owner of the second-best ditto ditto . .	15
3.	3.	To the owner of the best Cow in milk or in calf . .	20
		To the owner of the second-best ditto ditto . .	10
4.	4.	To the owner of the best Heifer in milk or in calf, not exceeding three years old	15
		To the owner of the second-best ditto ditto . .	10
		In the case of the cow or heifer, to which either of these prizes is awarded, being in calf, and not in milk, the prize will not be given until she is certified to have produced a live calf.	
5.	5.	To the owner of the best Yearling Heifer	10
		To the owner of the second-best ditto	5

Number of Certificate Form.	Class.	2.—HEREFORDS.	£.
6.	1.	To the owner of the best Bull, not exceeding five years old, calved previously to the 1st of January, 1850 .	40
		To the owner of the second-best ditto ditto . .	20
7.	2.	To the owner of the best Bull calved since the 1st of January, 1850, and more than one year old . . .	25
		To the owner of the second-best ditto ditto . .	15
8.	3.	To the owner of the best Cow in milk or in calf . .	20
		To the owner of the second-best ditto ditto . .	10
9.	4.	To the owner of the best Heifer in milk or in calf, not exceeding three years old	15
		To the owner of the second-best ditto ditto ditto .	10
		In the case of the cow or heifer, to which either of these prizes is awarded, being in calf, and not in milk, the prize will not be given until she is certified to have produced a live calf.	
10.	5.	To the owner of the best Yearling Heifer . . .	10
		To the owner of the second-best ditto	5

3.—DEVONS.

11.	1.	To the owner of the best Bull, not exceeding five years old, calved previously to the 1st of January, 1850 .	40
		To the owner of the second-best ditto ditto . .	20
12.	2.	To the owner of the best Bull calved since the 1st of January, 1850, and more than one year old . . .	25
		To the owner of the second-best ditto ditto . .	15
13.	3.	To the owner of the best Cow in milk or in calf . .	20
		To the owner of the second-best ditto ditto . .	10
14.	4.	To the owner of the best Heifer in milk or in calf, not exceeding three years old	15
		To the owner of the second-best ditto ditto . .	10
		In the case of the cow or heifer, to which either of these prizes is awarded, being in calf, and not in milk, the prize will not be given until she is certified to have produced a live calf.	
15.	5.	To the owner of the best Yearling Heifer . . .	10
		To the owner of the second-best ditto	5

4.—SUSSEX BREED.

16.	1.	To the owner of the best Bull, not exceeding five years old, calved previously to the 1st of January, 1850 . .	20
		To the owner of the second-best ditto ditto . .	10
17.	2.	To the owner of the best Bull calved since the 1st of January, 1850, and more than one year old . . .	10
18.	3.	To the owner of the best Cow in milk or in calf . .	10
		To the owner of the second-best ditto ditto . .	5
19.	4.	To the owner of the best Heifer in milk or in calf, not exceeding three years old	10
		In the case of the cow or heifer, to which either of these prizes is awarded, being in calf, and not in milk, the prize will not be given until she is certified to have produced a live calf.	
20.	5.	To the owner of the best Yearling Heifer . . .	5

5.—Other Breeds.

Not qualified to compete as Short-horns, Herefords, Devons, or Sussex Breed.

(Cross-bred Animals will be excluded.)

Number of Certificate Form.	Class.	£.
21.	1. To the owner of the best Bull, not exceeding five years old, calved previously to the 1st of January, 1850 . .	10
22.	2. To the owner of the best Bull calved since the 1st of January, 1850, and more than one year old . .	10
23.	3. To the owner of the best Cow in milk or in calf . .	10
24.	4. To the owner of the best Heifer in milk or in calf, not exceeding three years old	5
	In the case of the cow or heifer to which either of these prizes is awarded being in calf, and not in milk, the prize will not be given until she is certified to have produced a live calf.	
25.	5. To the owner of the best Yearling Heifer . . .	5

II.—HORSES.

26.	1. To the owner of the best Stallion for Agricultural purposes, foaled previously to the 1st of January, 1850 .	30
	To the owner of the second-best ditto ditto . .	15
27.	2. To the owner of the best Stallion for Agricultural purposes, foaled since the 1st of January, 1850 . .	20
	To the owner of the second-best ditto ditto . .	10
28.	3. To the owner of the best Roadster Stallion . . .	15
29.	4. To the owner of the best Mare and Foal for Agricultural purposes	20
	To the owner of the second-best ditto ditto . .	10
30.	5. To the owner of the best two-years old Filly ditto .	15
	To the owner of the second-best ditto ditto .	5

III.—SHEEP.

1.—Leicesters.

31.	1. To the owner of the best Shearling Ram . . .	30
	To the owner of the second-best ditto	15
32.	2. To the owner of the best Ram of any other age . .	30
	To the owner of the second-best ditto ditto . . .	15
33.	3. To the owner of the best pen of five Shearling Ewes of the same flock	20
	To the owner of the second-best ditto ditto . .	10

2.—South-Down, or other Short-woolled Sheep.

34.	1. To the owner of the best Shearling Ram . . .	30
	To the owner of the second-best ditto	15
35.	2. To the owner of the best Ram of any other age . .	30
	To the owner of the second-best ditto ditto . . .	15
36.	3. To the owner of the best pen of five Shearling Ewes of the same flock	20
	To the owner of the second-best ditto ditto . .	10

3.—Long-woolled Sheep:

Not qualified to compete as Leicesters.

Number of Certificate Form.	Class.		£.
37.	1.	To the owner of the best Shearling Ram . . .	20
		To the owner of the second-best ditto	10
38.	2.	To the owner of the best Ram of any other age . .	20
		To the owner of the second-best ditto ditto . . .	10
39.	3.	To the owner of the best pen of five Shearling Ewes of the same flock	10
		To the owner of the second-best ditto ditto . .	5

4.—Romney Marsh, or Kentish Sheep.

40.	1.	To the owner of the best Ram of any age . . .	20
		To the owner of the second-best ditto	10
41.	2.	To the owner of the best pen of 5 four-toothed Ewes with their Lambs	10
42.	3.	To the owner of the best pen of 5 Ewes of any age . .	10

IV.—PIGS.

43.	1.	To the owner of the best Boar of a large breed . .	15
		To the owner of the second-best ditto ditto . .	5
44.	2.	To the owner of the best Boar of a small breed . .	15
		To the owner of the second-best ditto ditto . .	5
45.	3.	To the owner of the best breeding Sow of a large breed .	10
46.	4.	To the owner of the best breeding Sow of a small breed . .	10
47.	5.	To the owner of the best pen of three Breeding Sow-pigs of a large breed, of the same litter, above four and under eight months old	10
48.	6.	To the owner of the best pen of three Breeding Sow-pigs of a small breed, of the same litter, above four and under eight months old	10

V.—POULTRY.

The arrangement of these Prizes will be decided on the 4th of February, 1852.

The Rules of Exhibition will be finally decided on the 4th of February, 1852.

By order of the Council,

JAMES HUDSON, *Secretary.*

London, December 11, 1851.